RAMA JUDICIAL

JUZGADO SÉPTIMO (7) CIVIL DEL CIRCUITO DE SANTIAGO DE CALI- VALLE

CONSTANCIA

Se corre traslado a las partes del dictamen pericial. Se fija por el término de tres (3) días. Corriendo los días 15, 16 y 17 de marzo de 2021

EDWARD OCHOA CABEZAS

Secretario

RAD : 201600298

REMISIÓN DICTAMEN PERICIAL CONFORME AUTO DE PRUEBAS #118 DEL 10 DE FEBRERO DE 2021 DTE Karen Fabiana Coronado Artunduaga RAD 760013103007 2016-00298-00

CARLOS ANDRES HERNANDEZ E <abogadoshernandezescobar@gmail.com>

Mié 10/03/2021 10:29

Para: Juzgado 07 Civil Circuito - Valle Del Cauca - Cali <j07cccali@cendoj.ramajudicial.gov.co>
CC: Luis Felipe Camacho Ramirez <lfcamachor@epscomfenalcovalle.com.co>; TORRES ABOGADOS <torresabogados2013@hotmail.com>; PAULA NATALIA CARREÑO CORREA <PNCARRENOC@compensar.com>

1 archivos adjuntos (2 MB)

DICTAMEN PERICIAL Compensar RAD 760013103007 201600298 00.pdf;

Doctor
LIBARDO ANTONIO BLANCO SILVA
JUEZ SÉPTIMO (07) CIVIL DEL CIRCUITO DE ORALIDAD DE CALI
Avenida 6 A Norte No. 28N – 23 Edificio Goya
E. S. D

REF.	***REMISIÓN DICTAMEN PERICIAL***
Radicado:	2016-0298
Proceso:	Verbal de Responsabilidad extracontractual
Demandante:	Karen Fabiana Coronado Artunduaga
Demandado:	Comfenalco Valle EPS
Llamado en Garantía:	**Caja de Compensación Familiar Compensar**

Conforme el asunto de la referencia, me permito remitir dictamen para conocimiento y fines pertinentes.

Cordialmente,

CARLOS ANDRES HERNANDEZ ESCOBAR
Apoderado COMPENSAR
C.C.79955080
T.P 154665
CEL Y WHATSUP 3012413045
abogadoshernandezescobar@gmail.com; oficinaHernandezescobar@gmail.com

DICTAMEN PERICIAL ESPECIALIDAD DE ORTOPEDIA

CASO DE RESPONSABILIDAD MÉDICA – KAREN FABIANA CORONADO ARTUNDUAGA

Se lleva a cabo el presente dictamen pericial a solicitud de la CAJA DE COMPENSACIÓN FAMILIAR COMPENSAR para ser aportado dentro del proceso de responsabilidad civil adelantado en su contra bajo el radicado 2016-0298 y que cursa en el Juzgado 7 Civil del Circuito de Cali.

A. Identificación del perito

Nombre: FABIAN GILBERTO GÓMEZ ARDILA
Cédula: 79948576
Especialidad: ORTOPEDIA Y TRAUMATOLOGÍA
Dirección: CR 7ª # 135-78 TORRE 4 APTO 903
Celular: 3024574606
Email: drfabiangomez78@gmail.com

B. Metodología

Para llevar a cabo el presente dictamen pericial se procedió a una lectura y estudio detallado de las historias clínicas de la Clínica Comfenalco Valle IPS SAS correspondientes a la atención de la señora Karen Fabiana Coronado Artunduaga, sumado a la revisión y conocimiento de artículos científicos, protocolos y guías médicas relacionadas .

C. Respuestas al cuestionario

A continuación procederé a dar respuesta a las siguientes preguntas formuladas por la CAJA DE COMPENSACIÓN FAMILIAR COMPENSAR con respecto a la atención médica brindada a la paciente KAREN FABIANA CORONADO ARTUNDUAGA:

1. Por favor explique de forma sencilla cómo es la composición ósea de los pies, identificando cada una de sus estructuras.

Respuesta:

La porción osea del pie puede dividirse en tres partes: Tarso, con siete huesos siendo, de atrás a delante el calcáneo, el astrágalo, el navicular, el cuboides y tres cuñas (primera o medial, segunda o intermedia y tercera o lateral).

HUESOS DEL RETROPIE:
Esta parte del pie está formada por los 2 huesos más grandes, que forman la articulación subastragalina:

-CALCÁNEO. Es el hueso más grande del pie y el que le da forma a nuestro talón. Está preparado para distribuir las presiones, ya que es el primero que recibe el impacto cuando se produce el paso. Por ello está recubierto de una gruesa capa de grasa que actúa de amortiguación. Por la parte de abajo posee una tuberosidad donde se inserta la fascia plantar.

-ASTRÁGALO. Es el segundo hueso más grande del pie y se sitúa justo encima del calcáneo. El astrágalo se encaja con la tibia y peroné para formar la articulación del tobillo, que nos permite plantarflexionar (bajar la punta del pie) o dorsiflexionar (llevar la punta del pie hacia arriba).

FUNCIÓN PRINCIPAL: La articulación subastragalina permite que nuestros pies hagan movimientos de pronación (el pie se va hacia adentro) o de supinación (el pie se va hacia afuera), además de estabilizar y distribuir las presiones al dar y apoyar el paso.

HUESOS DEL MEDIOPIÉ

En esta parte del pie se encuentran 5 huesos de un calibre menor a los dos anteriores:

-ESCAFOIDES O NAVICULAR. Se articula por su parte posterior con el astrágalo, por la parte lateral con el cuboides y en su cara anterior con las 3 cuñas. En su parte medial se inserta un tendón muy importante que se denomina tibial posterior.

-CUBOIDES. Con una forma que recuerda a un cubo, lo encontramos en la zona lateral del pie. Por su parte medial articula con el escafoides, por la parte posterior con el calcáneo y por su parte anterior con las bases del 4º y 5º metatarsiano.

-CUÑAS. En el pie tenemos 3 cuñas en total: cuña medial, cuña intermedia y cuña lateral. Junto con el cuboides forman la articulación tarsometatarsiana o de lisfranc, conectando con los metatarsos por sus caras anteriores.

FUNCIÓN PRINCIPAL: Amortiguación (junto a las articulaciones)

HUESOS DEL ANTEPIÉ

Por último, en el antepié tenemos 5 metatarsos y 14 falanges:

-METATARSOS. Son 5 huesos alargados cuya estructura es similar, pero con calibres distintos. Diferenciamos una zona final más abultada, llamada cabeza (que articula con los dedos y que es la que contacta con el suelo) y otra llamada cuerpo o diáfisis.

PRIMER METATARSIANO. Es el hueso metatarsiano de mayor calibre. Junto con la falange proximal del primer dedo forman la primera articulación metatarsofalángica que juega un papel muy importante a la hora de caminar, ya que es la que realiza el impulso en la fase final de la marcha y permite que el mecanismo de windlass se active.

2º,3º, 4º y 5º METATARSIANO. Poseen un menor calibre y se articulan en su cabeza con su correspondiente dedo. Son los más propensos a sufrir fracturas por estrés, siendo más habitual el segundo metatarso.

-FALANGES. En total poseemos 14 falanges en cada pie. En su base, las falanges proximales se articulan con los metatarsos.

2. Sírvase explicar en qué consiste un hallux valgus

Respuesta:

El hallux valgus, o juanete, es la desviación en valgo del primer Artejo con una desviación en varo del primer metatarsiano. El 90% de los pacientes son mujeres, siendo las limitaciones más frecuentes el dolor medial sobre la prominencia ósea, el dolor plantar bajo la cabeza de los metatarsianos y la aparición de ortejos en garra. El antecedente genético y el uso de calzados en punta son los factores asociados más importantes en el origen de este cuadro. La decisión de tratamiento está relacionada exclusivamente con la limitación que esta deformidad produce en el/la paciente. Es frecuente que pacientes que no acostumbran usar calzado ajustado nunca tengan síntomas, aunque tengan un hallux valgus grave. Por el contrario, personas que por su trabajo deben usar calzado formal/ajustado, pueden tener un juanete doloroso incluso con deformidades leves. Formas no quirúrgicas de tratamiento no corrigen el juanete. Las únicas maneras de aliviar los síntomas son utilizando zapatos anchos y/o plantillas en caso de metatarsalgia. La corrección quirúrgica se realiza mediante osteotomías, realineando la estructura ósea. Existen múltiples técnicas, las que se utilizan dependiendo de la severidad del cuadro y de la experiencia del cirujano. La cirugía tiene resultados satisfactorios en aproximadamente el 85% de los casos con alivio del dolor y de la deformidad como objetivos. El riesgo de complicaciones es del 15% aproximadamente, siendo las principales la recidiva de la deformidad, la presencia de osteosíntesis sintomática e infección superficial. El riesgo de recidiva aumenta en casos de deformidades graves, siendo la gran mayoría de las recidivas leves en magnitud y no siempre requieren cirugía.

Un 90% de los pacientes consultantes son de género femenino, que han portado la deformidad por largo tiempo y solicitan evaluación médica cuando esta comienza a ser limitante para su actividad funcional diaria. Clínicamente se manifiesta con dolor medial sobre la cabeza del primer metatarsiano al quedar esta más prominente por la desviación en valgo del ortejo mayor. La piel de esa zona se torna eritematosa y sensible por la constante presión que el calzado ejerce sobre ella. Los zapatos con taco y en punta son los que mayor presión generan sobre la zona de la primera articulación metatarsofalángica. Esta es la razón por la que la mayoría de los pacientes con HV sintomático son mujeres, y no porque la deformidad sea más frecuente en ellas, como tradicionalmente se pensaba.

Identificar la causa desencadenante del HV no ha estado exento de controversias. Se han postulado múltiples teorías pero ninguna ha sido aceptada unánimemente por la comunidad médica. Entre las causas intrínsecas que explicarían su desarrollo se pueden mencionar: inestabilidad cuneometatarsiana, que causaría la desviación a medial de este último hueso, con la consiguiente desviación a lateral del ortejo; malrotación metatarsiana con la consiguiente inestabilidad metatarso-falángica y del complejo sesamoideo, causando la desviación del ortejo mayor; insuficiencia de la cápsula/complejo ligamentario medial metatarsofalángico; desbalance muscular del complejo muscular del primer ortejo incluyendo flexores largo y corto y extensor largo del hallux, entre otros. La genética desempeña un claro rol en el HV, aunque aún una causa exacta no ha sido encontrada. Se ha descrito una prevalencia de HV de hasta un 94% en madres con hijos con HV. Sin duda que el factor extrínseco más determinante en el HV es el uso de zapato estrecho[5]. Esto se hizo evidente posterior a la Segunda Guerra Mundial, cuando aumentó la incidencia de HV en mujeres japonesas al comenzar a usar zapatos en punta y con taco.

3. De acuerdo con su experiencia y la literatura científica, por favor señale ¿cuál es el tratamiento gold standard para el manejo del hallux valgus?

Respuesta:
Dentro del manejo del HV el manejo conservador siempre ha sido recomendado previo a la cirugía. El tratamiento conservador no es capaz de restaurar la anatomía normal perdida. En la actualidad las exigencias de los pacientes hacen que sea de escasa utilidad plantear esta opción, que consiste en utilizar zapatos anchos, con el menor taco posible. Las zapatillas de deporte son ideales, ya que combinan una caja amplia para los ortejos, escaso realce en el talón, además de una superficie blanda. En casos extremos algunos pacientes hacen un agujero en el zapato en la zona del dolor (prominencia medial), logrando un alivio significativo del dolor. El uso de separadores de ortejos no ha demostrado ningún efecto en aliviar el HV, ya que lo único que logran es disminuir el valgo del hallux, pero manteniendo la prominencia medial del metatarsiano, que es la zona dolorosa. Además, una vez retirado el separador la deformidad del hallux vuelve, no teniendo ningún efecto a largo plazo. Las plantillas se recomiendan en casos de cuadros asociados, como es la metatarsalgia, el pie plano, entre otros, pero no para solucionar el HV en sí. Además, ejercicios de elongación del Aquiles son útiles en casos de pacientes con acortamiento del complejo gastro-sóleo para aliviar la metatarsalgia. Finalmente, se puede intentar recurrir a protecciones de silicona, u otro material blando, en la zona de dolor donde presiona el zapato para aliviar la presión directa.

Dentro de las opciones quirúrgicas hay más de 100 técnicas descritas en la literatura. En esta revisión se mencionarán someramente las que mayor apoyo tienen en la literatura, y por lo tanto son las que más se utilizan. En términos generales las opciones quirúrgicas se pueden separar en técnicas que actúan sobre las partes blandas y las que actúan sobre la alineación ósea. Las primeras se deben utilizar solo en asociación con técnicas de realineación ósea y jamás como técnica aislada de tratamiento, ya que aplicadas por sí solas tienen mayor riesgo de recidiva del HV. Incluso en deformidades leves, al comparar la osteotomía en Chevron con la plastia de McBride, la osteotomía presenta mejor resultado clínico y radiológico, además de una menor recidiva. La realineación ósea debe ser realizada por lo tanto a través de una osteotomía (corte en el hueso) y fijación posterior en la alineación correcta. Dónde y cómo realizar la osteotomía, así como los métodos de fijación de esta son los factores en los que se diferencian las distintas técnicas quirúrgicas.

4. Por favor explique, de manera sencilla, ¿en qué consiste la corrección quirúrgica con osteotomía metatarsiana?

Respuesta:

Técnicas quirúrgicas

Las técnicas que actúan a distal del metatarsiano (osteotomía en Chevron) están destinadas a corregir deformidades menores. Para mejorar la estabilidad de la osteotomía en Chevron se recomienda actualmente realizar la osteotomía en 90 grados, logrando así una rama horizontal de la osteotomía que le entrega mayor superficie de contacto, así como mayor facilidad para su fijación. Las que actúan a nivel diafisiario del 1.^{er} metatarsiano apuntan a una corrección de deformidades moderadas (por ejemplo Scarf) .Finalmente, las técnicas que actúan a nivel proximal en el 1.^{er} metatarsiano (por ejemplo osteotomías proximales o artrodesis tarsometatarsianas) deben aplicarse a casos de deformidad de HV grave. En casos de HV asociados a artrosis y/o HV severos la fusión de la articulación metatarsofalángica (artrodesis) es una opción a considerar, ya que será capaz de aliviar el dolor articular, además de corregir la deformidad por completo.

Recientemente se investigó el poder corrector de las osteotomías más utilizadas. En este metaanálisis se observó que la osteotomía distal en Chevron logra una corrección del ángulo intermetatarsiano de 5,3 grados. La osteotomía en Scarf logra corregir 6,2 grados. Finalmente, las osteotomías proximales lograron corregir 8,2 grados de ángulo intermetatarsiano, lo que representa una comprobación clínica de la teoría matemática en que procedimientos más proximales a la deformidad se consideran de mayor poder corrector que procedimientos distales.

Debemos siempre manejar variadas técnicas quirúrgicas, y establecer criterios claros para indicar una u otra. No es posible tratar todos los casos con una misma técnica quirúrgica, y esto debe ser evitado. Una de las alternativas de manejo de HV utiliza el concepto del ángulo a corregir, en que dependiendo de la cantidad de corrección necesaria se indica una técnica u otra en particular. Asimismo, cada técnica quirúrgica puede ser modificada para potenciar su capacidad correctora. Deberemos ser capaces de manejar alternativas quirúrgicas para la revisión de las fallas del tratamiento inicial, así como poder manejar técnicas quirúrgicas para deformidades primarias.

5. **Sírvase señalar ¿cuáles son los riesgos descritos por la literatura científica cómo inherentes a la corrección quirúrgica con osteotomía metatarsiana?**

Respuesta:

Las expectativas postratamiento son importantes de aclarar en la primera evaluación del paciente. Las expectativas más comunes son poder ocupar zapatos más angostos y pequeños, alivio del dolor, posibilidad de realizar deportes, poder estar de pie en el trabajo y en actividades sociales, entre otras. El objetivo principal de la cirugía es aliviar el dolor producido por el HV, siendo un objetivo secundario la estética . Es importante aclarar a los pacientes que hay un porcentaje de complicaciones inevitables. Además, el paciente debe comprender que el alivio del dolor, la vuelta al deporte de impacto y el uso de zapatos angostos y con taco no sucederá antes de 4 a 6 meses postoperatorio. Por lo general el retorno laboral ocurre a las 4-6 semanas. Resultados buenos y excelentes se observan en el 80-90% de los pacientes. Esto medido en escalas de funcionalidad (American Orthopedic Foot and Ankle Society) a mediano y largo plazo. El dolor se alivia significativamente (evaluado por la EVA) disminuyendo de un valor preoperatorio de 6-8/10 a alrededor de 1-2/10 en promedio.

Pueden ocurrir complicaciones hasta en el 15-20% de los casos. Dentro de las complicaciones se encuentran el dolor por elementos de osteosíntesis prominentes (5-10%), que en general comienza un año posterior a cirugía. La infección superficial y la dehiscencia de la herida operatoria ocurren en alrededor del 3-5% de los casos. La recidiva ocurre en promedio en el 3-5%, siendo la mayoría recidivas leves. El manejo de la recidiva se debe enfrentar desde el punto de vista radiológico y clínico. Si el paciente tuvo un alivio del dolor y su principal queja es por motivos estéticos, no se recomienda realizar una reoperación. Si esto no ha sido así se recomienda una reoperación, aumentando la potencia correctora de la técnica quirúrgica. Otras complicaciones ocurren en menos del 1% de los casos e incluyen, entre otras, dolor regional complejo, osteonecrosis, infección profunda, trombosis venosa profunda y no unión sintomática.

El hallux varus es una complicación desafortunada, estéticamente mal tolerada y funcionalmente importante por la dificultad de calzar zapatos adecuados.

Factores como plicación exagerada de la cápsula medial, excesiva resección de la eminencia medial, corrección exagerada del ángulo IM y liberación lateral con resección del sesamoideo lateral, son algunos de los problemas encontrados en esta complicación.

5.1. De acuerdo con lo manifestado en la respuesta inmediatamente anterior, por favor indique, en términos porcentuales, ¿cuál es la incidencia de hipercorrección de hallux valgus que se registra con posterioridad a la corrección quirúrgica con osteotomía metatarsiana?

Respuesta:
Menor del 10%

5.2. Sírvase precisar ¿en qué consiste la exostosis?

Respuesta:

La exostosis es el crecimiento anómalo de un hueso. Es un crecimiento benigno que puede rodearse de cartílago, conociéndose entonces como osteocondroma. Su situación es más común en los huesos largos, pero, se puede encontrar en cualquier hueso del cuerpo.

5.3. De conformidad con la revisión de la historia clínica, por favor señale si ¿a través del consentimiento informado se le indicaron la señora KAREN FABIANA CORONADO ARTUNDUAGA los riesgos inherentes más comunes de la corrección quirúrgica con osteotomía metatarsiana?

Respuesta:
Dentro de las complicaciones descritas en el consentimiento informado está la pérdida de la corrección, esta puede hacer referencia tanto a la reaparición de la deformidad original como a la aparicion de otra desviacion que incluiria el hallux varus POP. En este orden de ideas considero que se le informó a la paciente los riesgos inherenes de la cirugia dentro de los cuales esta la pérdida de la corrección.

6. Sírvase precisar si ¿el médico especialista en ortopedia y traumatología se encuentra capacitado para realizar una corrección quirúrgica con osteotomía metatarsiana?

Respuesta:
La cirugía de Hallux valgus es un procedimeinto muy frecuente en ortopepdia por la alta incidencia de la patologia, como ya se explico anteriormente. Esta cirugía puede ser realizada por ortopedistas generales y por subespecialistas en cirugía de pie y tobillo.

7. Partiendo de la revisión de la descripción quirúrgica de la cirugía practicada a la señora KAREN FABIANA CORONADO ARTUNDUAGA el 24 de septiembre de 2013, por favor señale ¿si la técnica quirúrgica utilizada por el Doctor Carlos Arturo Lemos Torres se ajustó a las guías y protocolos médicos?

Respuesta:
Como lo dije anteriormente las posibilidades de manejo quirugico para el hallux valgus con corrección ósea, son múltiples y la elección de cada técnica depende de la experiencia de cada

cirujano, y de la situación puntual de cada paciente. Las osteotomias proximales estan descritas como tecnica quirurgica para realinear el primer metatarsiano.

8. Por favor señale ¿cuál es el seguimiento postoperatorio que debe hacerse a un paciente que ha sido sometido a corrección quirúrgica con osteotomía metatarsiana?

Respuesta:
Hoy en día se sabe que el pie y el tobillo se rehabilita antes y mejor después de una cirugía, al ser sometido a carga precoz. Por ello en un paciente operado de HV se aconseja iniciar carga lo antes posible, es decir, al cabo de 3 o 4 días postoperado, con un zapato adaptado para ello y eventualmente bastones. Después de 4 o 5 semanas ya estará capacitado para usar calzado ancho y firme, y podrá volver a su actividad laboral, entendiendo que el proceso de consolidación aún estará en desarrollo. El manejo del edema es fundamental, ya que se encuentra siempre presente los primeros 3 meses después de la cirugía, independiente de la técnica utilizada, disminuyendo gradualmente. Para esto se pueden emplear vendajes elásticos, como los utilizados en la insuficiencia venosa, además de drenaje linfático en algunos casos.

9. En su consideración, ¿el seguimiento postoperatorio que se le realizó a la señora KAREN FABIANA CORONADO ARTUNDUAGA fue correcto, oportuno y adecuado?

Respuesta:
El seguimiento del POP fue adecuado según lo que encuentro en la historia clinica, lo que permitio evidenciar en el tiempo como se procedió la corrección y como aparecieron las complicaciones, condición que permitió hacer la propuesta de nueva intervención para corregir las complicaciones.

10. Por favor informe si ¿la hipercorrección y exostosis pueden ser objeto de nueva corrección o si, por el contrario, se tratan de patologías que no cuentan con un tratamiento curativo? En caso positivo, por favor identifique la conducta médica a seguir.

Respuesta:
Esta descrito en la literatura de las complicaciones el manejo para la corrección de la defermidad residual, y la cirugia para corregir las complicaciones es el procedimiento a seguir para recuperar la alinacion del hallux y la resección de la exostosis descrita. La respues es, si hay manejo y este es una nueva cirugía correctiva tanto para la sobre corrección como para la resección de la exostosis.

11. ¿Considera usted que en el caso de la señora KAREN FABIANA CORONADO ARTUNDUAGA se le ofrecieron los tratamientos disponibles en la ciencia médica para el manejo de la hipercorrección y exostosis?

Respuesta:
Si. Dentro del manejo de las complicaciones esta el llevar al paciente nuevamente a cirugía para la corrección de la deformidad residual, y eso hace parte del buen ejercicio y el acompañamiento del paciente para reposición de la biomecanica de la marcha, para este caso puntual.

12. Por favor señale si en su consideración, ¿el tratamiento brindado a la señora KAREN FABIANA CORONADO ARTUNDUAGA se ajustó a la lex artis?

Respuesta:
Como ya lo comente. El manejo para la defomirdad en hallux valgus es la cirugía, la osteotomia proximal esta descrita como parte del arcenal quirúrgico para la corrección. En los casos de aparición de complicaciones como las ocurridas en la paciente en cuestión, la decisión está en llevar nuevamente a cirugía para corregir las deformidades residuales y restaurar la biomecanica del pie buscando la disminución del dolor.

D. Consideraciones

Manifiesto que no me encuentro incursa en algunas de las causales establecidas en el artículo 50 del C.G.P. y que actualmente no tengo un vínculo con la Caja de Compensación Familiar Compensar

En el presente dictamen no he utilizado métodos, experimentos o investigaciones diferentes a las usadas habitualmente en el desarrollo de mi ejercicio profesional o de dictámenes periciales rendidos en otras oportunidades.

A la fecha no he rendido mi concepto médico en ningún otro proceso (en caso contrario, identificar el proceso con juzgado, radicado y partes).

E. Bibliografía

1. R.A. Fuhrmann, H. Zollinger-Kies, H.P. Kundert.
Mid-term results of Scarf osteotomy in hallux valgus.
Int Orthop, 34 (2010), pp. 981-989

2. D.E. Lehman.
Salvage of complications of hallux valgus surgery.
Foot Ankle Clin, 8 (2003), pp. 15-35

3. S.B. Shawen, T. Dworak, R.B. Anderson.
Return to play following ankle sprain and lateral ligament reconstruction.
Clin Sports Med, 35 (2016), pp. 697-709

4. K.D. Merkel, Y. Katoh, E.W. Johnson Jr., E.Y. Chao.
Mitchell osteotomy for hallux valgus: long term follow-up and gait analysis.
Foot Ankle, 3 (1983), pp. 189-196

5. R. Schuh, M. Willegger, J. Holinka, R. Ristl, R. Windhager, A. Wanivenhaus.
Angular correction and complications of proximal first metatarsal osteotomies for hallux valgus deformity.
Int Orthop, 37 (2013), pp. 1771-1780

6. E. Wagner, C. Ortiz, F. Figueroa, O. Vela, P. Wagner, J. Gould.
Role of a limited transarticular release in severe hallux valgus correction.
Foot Ankle Int, 36 (2015), pp. 1322-1329

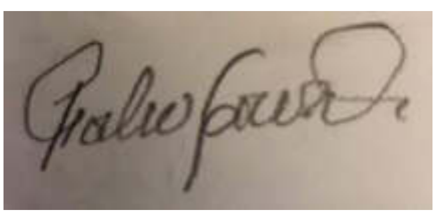
7. G. Choi, H. Kim, T. Kim, S. Chun, T. Kim, Y. Lee, *et al*.
Comparison of the modified McBride procedure and the distal Chevron osteotomy for mild to moderate hallux valgus.
J Foot Ankle Surg, 55 (2016), pp. 808-811

8. T.N. Joseph, K.J. Mroczek.
Decision making in the treatment of hallux valgus.
Bull NYU Hosp Jt Dis, 65 (2007), pp. 19-23

9. J.H. Choi, J.R. Zide, S.C. Coleman, J.W. Brodsky.
Prospective study of the treatment of adult primary hallux valgus with scarf osteotomy and soft tissue realignment.
Foot Ankle Int, 34 (2013), pp. 684-690

F. <u>Anexos</u>

Hoja de Vida
Diplomas y títulos académicos



Firma

FABIAN GILBERTO GÓMEZ ARDILA

Cc: 79948576

ORTOPEDIA Y TRAUMATOLOGÍA

FABIAN GILBERTO GOMEZ ARDILA
Ortopedia y Traumatología

Dirección:	Cra 7ª # 135-78 t 4 apt 903
Teléfono:	7592208
Celular	3024574606
Bogotá D. C.	
Registro medico:	86 1715 de ministerio de protección social
Correo electrónico:	fabiangomez7807@gmail.com

DATOS PERSONALES

Lugar y fecha de nacimiento	Bogotá, 18 de julio de 1978
Cédula de Ciudadanía	79.948.576 Expedida en Bogotá
Estado Civil	casado
Nacionalidad	colombiano

INFORMACION ACADEMICA

Primaria	Colegio San Bartolomé La Merced, 1989
Secundaria	Colegio Liceo Boston, 1996, Bachiller Académico
Universitarios	Fundación Universitaria Ciencias a la Salud Hospital de San José
Título	Médico y Cirujano, 2005.
	Ortopedia y Traumatologia, 2014, FUNDACION UNIVERSITARIA SANITAS

Cursos de Actualización

- Actualización en el Tratamiento de las Alergias, septiembre de 2001
- Avances en la Terapia de la Diabetes Mellitus, marzo, 2002
- Noveno Congreso Colombiano de Psiquiatría, Abril, 2002
- Actualización en Neurociencias, Agosto 2002,
- Pasantía Servicio de Cirugía Plástica, Hospital San José, Junio de 2004
- Año de Internado, Hospital San José, Diciembre 10 de 2005.
- BLS, FUCS Hospital de San José, 2007
- ACLS, FUCS Hospital de San José, 2007
- Curso de Cirugía de la Mano, Clinica Marly, 2010
- XIV Curso internacional de ortopedia. Octubre de 2010
- III Curso de habilidades y entrenamiento en microcirugía. Febrero 2011
- LXXXIX Curso de actualización y entrenamiento en en habilidades de cirugía artroscopica. Agosto 2011
- Congreso Nacional de la Sociedad Colombia de Ortopedia y Traumatología, Mayo 2011
- IV Curso Colombiano de medicina del football y trauma deportivo. Actualización en trauma deportivo pediatrica. Marzo de 2012
- Curso básico de protección radiológica. Agosto 2012
- Congreso de la Asociación Colombia de Cirugía de la Mano, Julio 2013
- Congreso Nacional de la Sociedad Colombia de Ortopedia y Traumatología, Mayo 2013
- XVI Cueso Internacional De ortopedia. Sociedad colombiana de ortopedia y Traumatologia regional centro. clínicas Colsanitas. Noviembre 2013
- Curso del capítulo de Cirugía de Columna, Noviembre de 2013
- AO Trauma Básico. Febrero 2014

PUBLICAIONES

- FABIAN GOMEZ ARDILA, “Aproximación a los enfoques terapéuticos actuales en ontogénesis imperfecta a partir de la biología de la enfermedad “ Colombia, Revista de la Sociedad Colombia de Ortopedia y Traumatología , *ISSN:* 0120-8845 *ed: vol 25 2011 Num 1 pag 50-58*
- FABIAN GOMEZ ARDILA, “ Descripción anatomía de la membrana interósea del antebrazo : estudio en cadáveres” Colombia, Revista de la Sociedad Colombia de Ortopedia y Traumatología , *ISSN:* 0120-8845 publicado por ELSEVIER España 2013;27(3):140-143
- FABIAN GOMEZ ARDILA, “Asociación de hemimelia de peroné y pie equino varo, reporte de caso “ 2104. *P,* , Revista de la Sociedad Colombia de Ortopedia y Traumatología , *ISSN:* 0120-8845 publicado por ELSEVIER España 2013;27(4):210-221
- FABIAN GOMEZ ARDILA, POSTER CIENTIFICO, “Osteotomía periacetabular modificada en enfermedad de Perthes y evidencia radiología de extrusión de la cabeza femoral. Descripción de técnica quirúrgica y

experiencia clínica " 58 congreso Nacional de la Sociedad Colombiana de Ortopedia y Traumatología. Mayo 2013

CONFERENCIAS

- OSTEOTOMIA PERIACETABULAR MODIFICADA EN ENFERMEDAD DE PERTHES , XVI CURSO INTERNACIONAL DE ORTOPEDIA SOCIEDAD COLOMBIANA DE ORTOPEDIA Y TRAUMATOLOGIA REGIONAL CENTRO, CLINICAS COLSANITAS NOVIEMBRE DE 2013

EXPERIENCIA PERSONAL

Experiencia Clínica, Hospital San José.

Servicio Social Obligatorio ECOPETROL S.A. ORITO PUTUMAYO. 2006

PRIDE COLOMBIA SERVICES, BOGOTA, 2007

Consulta externa, POLICIA NACIONAL DE COLOMBIA, 2007

Ayudante de quirúrgico, CLINICA LA CAROLINA, 2008-2009

Medico consulta prioritaria ortopedia y traumatología, INSTITUTO DE ORTOPEDIA Y CIRUGIA PLASTICA, 2008-2010

Ayudante quirúrgico, CECIMIN, 2008-2010

Residente de Ortopedia y Traumatología, FUNDACION UNIVERSITARIA SANITAS, 2010-2014

Medico consulta Prioritaria, INSTITUTO DE ORTOPEDIA Y CIRUGIA PLASTICA, 2010-2014

ORTOPEDISTA, Consulta prioritaria INSTITUTO DE ORTOPEDIA Y CIRUGIA PLASTICA, 2014
ORTOPEDISTA, Organizacion SANITAS INTERNACIONAL, EPS SANITAS. Septiembre 2014
ORTOPEDISTA, CAFAM. Septiembre 2014
ORTOPEDISTA Famisanar Plan Complementario. Noviembre 2015
ORTOPEDISTA Allianz Colombia. Noviembre 2015
ORTOPEDISTA Generalli Colombia. Noviembre 2015

ORTOPEDISTA Adscrito Clinica Palermo. Septiembre 2014
ORTOPEDISTA Adscrito Clinica VIP. Septiembre 2015
ORTOPEDISTA Adscrito Clinica Los Nogales. Abril 2016
ORTOPEDISTA Adscrito Instituto de Ortopedia y Cirugia Plastica. Septiembre 2014

REFERENCIAS PERSONALES

Dr. Cesar Alvarado. Ortopedista Traumatólogo. Expresidente Sociedad Colombiana de Cirugía ortopédica y traumatología
Instituto de Ortopedia y Cirugía Plástica.
Tel: 6190311

Dr. Gilberto Sanguino, Ortopedista Traumatólogo, Cirugía de Rodilla, Clínicas Colsanitas. COLTRAUMA
TEL: 2202727

Dr. Roberto Melendez, Ortopedista Traumatólogo, Cirujano de Mano, Clínicas Colsananitas, Clinica Reina Sofía, CECIMIN
TEL: 3102543439

FABIAN GOMEZ ARDILA

SOSIRAD LTDA.

SALUD OCUPACIONAL • SEGURIDAD INDUSTRIAL • RADIACIONES

Licencia Min. Protección Social Resolución 334 de 2011 NIT 900.334.393-8

CERTIFICA

Que el Doctor: **FABIAN GILBERTO GOMEZ ARDLA**

Identificado con la cédula de ciudadanía No. 79.948.576 asistió al **CURSO BASICO DE PROTECCIÓN RADIOLOGICA**, dictado en la ciudad de Bogotá, los días **24 y 25** de Agosto de 2012, con una intensidad de **30** horas.

En constancia firma

HECTOR FABIO CARDENAS C.
Físico e Ingeniero Nuclear
Especializado en Seguridad Radiológica
Licencia Minsalud No. 001893 de 22/05/98


SECRETARIA DISTRITAL DE SALUD DE BOGOTA
CERTIFICADO DE INSCRIPCION
FABIAN GILBERTO
GOMEZ ARDILA
C.C 79948576
MEDICO(A)
ALCALDIA MAYOR DE BOGOTA
FIRMA AUTORIZADA
Scanned by CamScanner


REPUBLICA DE COLOMBIA
MINISTERIO DE LA PROTECCION SOCIAL
TARJETA PROFESIONAL DE MEDICO
Registro No.
86 1715/ 2006
Libertad y Orden
Firma Médico
Nombres y Apellidos
FABIAN G. GOMEZ ARDILA
C.C. o C.E. C 79948576 De BOGOTA
Universidad FUND.UN.CIENCIAS D Ciudad BOGOTA
Código 48689/01
Fecha de Expedición 09/11/06


REPUBLICA DE COLOMBIA
IDENTIFICACION PERSONAL
CEDULA DE CIUDADANIA
79.948.576
GOMEZ ARDILA
APELLIDOS
FABIAN GILBERTO
NOMBRES
FIRMA

Centro Latinoamericano de Investigación
y Entrenamiento en Cirugia de
Mínima Invasión - CLEMI

Certifica que

Fabián Gómez Ardila MD

Participante

Asistió al

LXXXIX Curso de Actualización y Entrenamiento en habilidades para
Cirugía Artroscopia

Bogotá – Colombia Agosto 22 y 23 de 2011
Intensidad: 18 Horas

Gabriel Oswaldo Alonso MVZ
Coordinador de Formación
CLEMI

República de Colombia
Ministerio de Educación Nacional
y en su nombre la

Fundación Universitaria de Ciencias de la Salud

Personería Jurídica 10917 del 1° de Diciembre de 1976 del Ministerio de Educación Nacional

Facultad de Medicina

En atención a que

Fabián Gilberto Gómez Ardila

C.C. 79.948.576 Stafé de Bogotá

Cumplió satisfactoriamente con todos los requisitos del plan de estudios, le confiere el título de

Médico y Cirujano

En testimonio de ello se firma y refrenda con los respectivos sellos en Bogotá, D.C., a los 16 de Diciembre de 2005

Presidente Consejo Superior

Rector

Vicerrector

Secretario General

Decano

Secretaria Académica

Número de Registro 0123 Número de Folio 006
Bogotá D.C. Dic. 16 de 2005

00698

FUNDACIÓN UNIVERSITARIA SANITAS
ORGANIZACIÓN SANITAS INTERNACIONAL

Personería jurídica reconocida mediante Resolución No. 3015 del 23 de diciembre de 2002

FACULTAD DE MEDICINA

ACTA DE GRADO No. EP099
(Folio 00099 del libro EP01)

En la ciudad de Bogotá, a los veintiocho (28) días del mes de agosto del año dos mil catorce (2014), la Fundación Universitaria Sanitas, en nombre de la República de Colombia y con autorización del Ministerio de Educación Nacional de la misma, como consta en el registro SNIES No. 54049, llevó a cabo el acto solemne de graduación mediante el cual, previo juramento, otorga el título de

ESPECIALISTA EN ORTOPEDIA Y TRAUMATOLOGÍA

A

FABIÁN GILBERTO GÓMEZ ARDILA

Identificado(a) con C.C. No. 79.948.576 de Bogotá, quien cumplió con los requisitos académicos, legales y reglamentarios establecidos para conferir dicho título profesional. Por lo tanto, se le hizo entrega del Diploma No. 14BO57EP000099 que lo(a) acredita como tal.

Para constancia se expide y firma la presente Acta, válida para todos los efectos correspondientes.

Firmada por: **MARIO ARTURO ISAZA RUGET** - Rector, **JUAN DE FRANCISCO ZAMBRANO** - Decano Facultad de Medicina, y **JOHNS STEVE NAVARRO LARA** - Secretario General.

Es fiel copia tomada del original, expedida en Bogotá, el veintiocho (28) de agosto del año dos mil catorce (2014).

JOHNS STEVE NAVARRO LARA
Secretario General

FUNDACIÓN UNIVERSITARIA DE CIENCIAS DE LA SALUD

Personería Jurídica 10917 del 1° de Diciembre de 1976 del Ministerio de Educación Nacional

Acta de Grado No. 005

En la ciudad de Bogotá, D.C. dieciséis (16) de diciembre de 2005, en el Auditorio Guillermo Fergusson, del Hospital de San José, de conformidad con el Acuerdo Número 1061 del Consejo Superior de la Fundación Universitaria de Ciencias de la Salud. Sesión Ordinaria No. 182 del (6) de diciembre de 2005se realizó acto solemne para otorgar el título de :

Médico y Cirujano

A

FABIÁN GILBERTO GÓMEZ ARDILA

Identificado (a) con C.C. número 79,948,576 expedida en Santafé de Bogotá DC como consta en el acta número 005 del libro de actas de grado de la Facultad de MEDICINA

Se confiere el título en nombre del Ministerio de Educación Nacional en reconocimiento a que el mencionado estudiante cursó y aprobó todas las asignaturas del pénsum reglamentario para el programa de MEDICINA y llenó todos los requisitos exigidos para el efecto por la Fundación Universitaria de Ciencias de la Salud.

Para constancia de lo anterior se firma la presente acta en Bogotá, D.C. a los (16) días de diciembre de 2005 .

Presidente Consejo Superior

Rector

Vicerrector

Secretario General

Decano

Secretario Académico

00536

THOMAS GREG & SONS.

Centro Latinoamericano de Investigación
y Entrenamiento en Cirugía de
Mínima Invasión - CLEMI

Certifica que

Fabián Gómez Ardíla MD

Participantes

Asistió al

III Curso de Actualización y Entrenamiento en Habilidades para Microcirugía

Bogotá – Colombia Febrero 18 y 19 de 2011
Intensidad: 18 Horas

Francisco José Camacho MD
Director de Investigación, Patentes y Desarrollo CLEMI
Coordinador Curso

Gabriel Oswaldo Alonso MVZ
Coordinador de Formación
CLEMI

Jorge Felipe Ramírez MD
Presidente CLEMI

AOTRAUMA
LATIN AMERICA

Course Participant Certificate

Certifica que

Fabian Gómez

Ha participado en el

AOTrauma Curso - Básico de los Principios del Tratamiento de las Fracturas

Fecha/Ciudad

Febrero 19 - 22, 2014 Medellín, Colombia

Director del Curso

Claudia Medina

Niklaus Renner
Chairperson AOTrauma Board

Jaime Quintero
President AO Foundation

This certificate pertains only to the participant's completion of the educational activity and does not in any way attest to the proficiency of the participant's clinical or surgical expertise

República de Colombia

FUNDACIÓN UNIVERSITARIA SANITAS

Personería Jurídica No. 3015 del 23 de diciembre de 2002

Considerando que

Fabián Gilberto Gómez Ardila

C.C. 79.948.576 de Bogotá

Cumplió los requisitos académicos exigidos para optar al grado de especialista, le confiere el título de

Especialista en Ortopedia y Traumatología

En testimonio de ello se firma y refrenda con los respectivos sellos el presente Diploma en Bogotá D.C. a los veintiocho (28) días del mes de agosto del año dos mil catorce (2014)

Mario Arturo Isaza Ruget
Rector

[illegible] Francisco Zambrano
Decano

John Steve Navarro Lara
Secretario General

Anotado al Folio No.00099 Libro de registro No. EP01
14BO57EP000099

International Orthopaedics (SICOT) (2010) 34:981–989
DOI 10.1007/s00264-010-0958-z

ORIGINAL PAPER

Mid-term results of Scarf osteotomy in hallux valgus

Renée A. Fuhrmann · Hans Zollinger-Kies · Hans-Peter Kundert

Received: 19 April 2009 / Revised: 10 January 2010 / Accepted: 11 January 2010 / Published online: 16 February 2010

Abstract We performed a retrospective study on 178 Scarf osteotomies with a mean follow-up of 44.9 months (range 15–83 months). Clinical rating was based on the forefoot score of the American Orthopaedic Foot and Ankle Society (AOFAS). Weight bearing X-rays were used to perform angular measurements and assess the first metatarsophalangeal joint (MTP 1). At follow-up the mean AOFAS score had improved significantly ($p<0.001$), but only 55% of the feet showed a perfect realignment of the first ray. Patients with a hallux valgus angle exceeding 30° and pre-existing degenerative changes at the MTP 1 joint displayed inferior clinical results ($p<0.05$). Nearly 20% of the patients suffered from pain at the MTP 1 joint. This was clearly attributed to an onset or worsening of distinct radiographic signs of arthritis ($p<0.05$) resulting in painfully decreased joint motion. Comparing radiographic appearance three months postoperatively and at follow-up, we found that radiographic criteria (hallux valgus, first intermetatarsal angle, hallux valgus interphalangeus, MTP 1 joint congruency, arthritic lesions at MTP 1) worsened with time.

R. A. Fuhrmann (✉)
Department of Orthopaedic Surgery, Rudolf-Elle-Hospital,
University of Jena,
Klosterlausnitzerstr. 81,
07607 Eisenberg, Germany
e-mail: RAEFuhrmann@aol.com

H. Zollinger-Kies · H.-P. Kundert
Foot and Ankle Center, Hirslanden Clinic,
8008 Zürich, Switzerland

H. Zollinger-Kies
e-mail: h.zollinger-kies@access.uzh.ch

H.-P. Kundert
e-mail: hpkundert4foot@bluewin.ch

Introduction

Correction of hallux valgus deformities requires soft tissue procedures and a first ray osteotomy. Apart from accepted standards to realign the soft tissues at the first metatarsophalangeal joint there is ongoing discussion about the various metatarsal osteotomies. Multiplanar diaphyseal metatarsal osteotomies are considered to have some advantages over distal and proximal osteotomies, although modifications of distal osteotomies also allow three dimensional correction [13]. As the transversal plane of the bone cut runs almost parallel to the plantar surface of the foot, plantigrade weight bearing leads to compression and inherent stability at the site of osteotomy. This has been proven biomechanically [23]. Aiming the diaphyseal bone cut plantarwards allows adjustment of the plantar pressure in cases of transfer metatarsalgia. Finally, rotation of the metatarsal head can be performed to realign the distal metatarsal articular surface. As a result of these principal advantages Scarf osteotomy, which was first described by Burutaran in 1976 [4], has gained wide popularity.

Nevertheless, the diaphyseal osteotomy requires an extensive exposure of the entire metatarsal and even a great protagonist of the Scarf osteotomy states that the surgical technique could be technically demanding [3, 8]. Therefore, discussion has arisen as to whether the results of Scarf osteotomy are superior to technically more simple osteotomies at the distal and proximal metatarsal. Although some clinical follow-up studies have been published in the last decade, most of them refer to short-term or mid-term results and others subsumed patients requiring a Scarf osteotomy and additional osteotomies of the lesser metatarsals [2, 7, 12, 16]. To evaluate the long-term results of isolated Scarf osteotomies in patients with isolated hallux valgus deformity the authors decided to perform a multicentre study.

Materials and methods

One hundred and sixty-two patients (156 female, six male) with hallux valgus deformity treated between 1995 and 2001 were included in the study. Thirty-seven patients underwent bilateral surgery resulting in a total number of 199 feet. Complex forefoot malalignment requiring additional osteotomies at the lesser metatarsals, patients with previous forefoot surgery and patients with rheumatoid arthritis or neurological disorders were excluded from the study. The indications referred to a first intermetatarsal angle of less than 20 degrees with no restrictions regarding the hallux valgus angle. Minor radiological signs of arthritis at the first metatarsophalangeal (MT 1) joint were no contraindication as long as the patients were asymptomatic and range of motion was not reduced below 60 degrees. Mean age at the time of operation was 53.8 years (range 17–77 years). After a mean follow-up of 44.9 months (range 15–83 months), 149 patients (91.9%) (178 feet, 91.8%) attended a clinical and radiological follow-up. In the meantime, three patients had died, five moved away, and five refused to further participate in the study.

All feet were exclusively operated and followed-up by the three authors. The surgical technique mainly followed the instructions published by Barouk [3]. A straight incision was performed on the medial side of the first ray. To release the lateral soft tissues a transarticular approach was chosen in 65 feet (36.5%). In 113 feet (63.5%) the lateral release was carried out through a separate incision along the first web space. The distal starting point of the Z-shaped osteotomy was approximately 5 mm proximal to the cartilage surface. Leaving the plantar two thirds of the metatarsal undamaged, the bone cut pointed slightly plantarwards. The proximal end of the osteotomy was located 10 mm distal to the metatarso-cuneiform (MC) joint. To release the two bone fragments the osteotomy was completed by two short transverse cuts at both ends of the longitudinal osteotomy. These two parallel cuts were performed at a 60° angle to the longitudinal axis. After carefully releasing both fragments the plantar metatarsal portion was shifted laterally. In order to obtain correction of the distal metatarsal articular angle the proximal part of the plantar fragment was pivoted to the lateral side. Internal fixation was achieved with two cannulated screws (Herbert type). After the medial border of the bunion was trimmed, a moderate medial capsular reefing was followed by the skin closure. Then a bulky dressing was applied. Patients were asked to stay in bed for 24 hours with the operated foot elevated. Immediate weight bearing was allowed using a forefoot relief orthosis for four weeks. Patients were instructed to perform active and passive exercises of the MTP 1 joint and tape the great toe into a straight position. Four weeks postoperatively a check X-ray was performed. If sufficient healing of the osteotomy was revealed, patients were allowed to wear trainers.

In cases of concomitant hallux valgus interphalangeus deformity of more than 10 degrees, an Akin procedure of the proximal phalanx was additionally carried out in 37 feet (20.8%). To correct fixed hammertoe deformity, resection arthroplasty or arthrodesis (59 feet, 33.1%) was performed at the proximal interphalangeal joint. To address flexible hammer toe deformities a flexor-to-extensor-transfer was indicated in 12 feet (6.7%).

At the latest follow-up clinical evaluation was based on the AOFAS metatarsophalangeal-interphalangeal score [11]. Besides the clinical assessment of the first ray, we looked for signs of central metatarsalgia.

Standardised weight bearing radiographs allowed comparison of preoperative and postoperative findings: first intermetatarsal angle, hallux valgus angle, hallux valgus interphalangeus angle, distal metatarsal articular angle, joint congruency at the first metatarsophalangeal joint, length of the first metatarsal, metatarsal alignment, arthritic changes at the first metatarsophalangeal joint and the alignment of the first metatarso-cuneiform joint [1, 20]. These radiographic parameters were evaluated preoperatively, three months after surgery, and at follow-up.

Statistical assessment included a paired resp. unpaired t-test and a linear regression analysis. Differences in p values less than 0.05 were considered statistically significant.

Results

Clinical assessment

Pain (40 points) decreased from a mean value of 17.9 points preoperatively to 36.8 points postoperatively ($p<0.001$) (Table 1).

Within the functional assessment (45 points) (Table 2), activity (mean preoperative value 5.4 points and 8.9 points postoperatively, $p<0.001$) and footwear requirements (mean preoperative value 5.8 points / 8.6 points postoperatively, $p<0.05$) improved significantly.

Table 1 Assessment of pain according to the American Orthopaedic Foot and Ankle Society (AOFAS) score

Preoperative pain		Postoperative pain			
		Severe	Moderate	Mild	None
Severe	20	6	4	10	0
Moderate	139	6	16	0	117
Mild	19	0	2	4	13

Although range of motion at the MTP 1 joint did not reveal significant changes (mean preoperative value 7.2 points and 8.4 points postoperatively; $p>0.05$), 22% of the joints showed impaired function at follow-up. Re-evaluating the preoperative X-rays we found a significant correlation ($p<0.05$) between signs of arthritic changes and restricted range of motion postoperatively.

Plantarflexion at the first interphalangeal (IP) joint decreased significantly (mean preoperative value 4.9 points and 3.5 points postoperatively; $p<0.05$). At follow-up, 19.7% of the patients had impaired IP 1 joint function. We found no correlation to any radiographical findings, hallux valgus angle, hallux valgus interphalangeus angle, or ROM at the MTP 1 joint.

Although MTP 1 stability improved significantly (mean preoperative value 1.9 points and 4.9 points postoperatively; $p>0.01$), 35.9% of joints were considered unstable at follow-up. Instability at MTP 1 could be correlated to a recurrent deformity ($p<0.05$). Stability at IP 1 was not influenced by the metatarsal osteotomy. Callus was reduced significantly (mean preoperative value 1.3 points and 5.4 points postoperatively, $p>0.001$).

Alignment of the great toe also improved significantly (mean preoperative value 1.4 points and 12.7 points postoperatively; $p<0.001$) (Table 3). Of the treated feet, 24.2% showed a mild hallux valgus deformity (≤ 20 degrees) and 19.7% revealed a moderate recurrent malalignment (≥ 21 degrees). Hallux varus occurred in 1.6%.

Overall the AOFAS score improved significantly ($p<0.001$) (Table 4). The mean preoperative value (45.8 points) increased to 89.4 points at follow-up (Fig. 1). Pain, function, and alignment displayed a significant improvement, whereas ROM at MTP 1 / IP 1, stability at MTP 1 and toe alignment revealed a significant ($p<0.05$) worsening with time.

To evaluate the influence of patient's age we categorised two groups: (A)≤50 years and (B) >51 years. The mean preoperative / postoperative values of the AOFAS score displayed no significant differences in both groups (A: 44.6 / 91.3 points and B: 47.0 / 86.9 points).

Furthermore, we analysed whether the degree of hallux valgus (HV) deformity had influenced the clinical outcome. Therefore we categorised two groups of patients: (A) HV angle ≤ 30° (62 feet), (B) HV angle ≥ 31° (116 feet). For patients in groups A and B the mean AOFAS scores were 50.1 and 43.5 points preoperatively, respectively, and 94.8 / 86.7 points postoperatively. By linear regression analysis we found that the preoperative HV angle had a significant effect on the AOFAS score ($p<0.05$).

Finally we examined the influence of the first intermetatarsal (IM) angle on the clinical outcome. Again, two groups were considered: (A) IM 1 angle ≤ 13° (61 feet), (B) IM 1 angle ≥ 14° (117 feet). According to the AOFAS scores, the patients in groups A and B displayed mean preoperative values of 49.9 and 52.4 points, respectively, and 90.8 and 87.7 points postoperatively. These results did not reach statistical significance.

Metatarsalgia

Preoperatively more than half of the patients (99 feet, 55.6%) had no symptoms or clinical signs for metatarsalgia. At follow-up, nine of these patients complained of central metatarsalgia.

Most patients suffering from metatarsalgia preoperatively (79 feet, 44.4%) were free of pain (60 feet) at follow-up. The remaining patients (19 feet) stated that the symptoms had not changed.

Radiological assessment

Hallux valgus (HV) angle measurements (Table 5) were based on the recommendations from the Ad Hoc Committee of the American Orthopaedic Foot & Ankle Society [6, 16].

The mean HV angle (39° preoperatively / 12.5° postoperatively) was significantly reduced ($p<0.001$) after the operation. At the latest follow up we recorded a significant recurrence (mean HV angle 24.8°) ($p<0.05$).

The first intermetatarsal (IM) angle was significantly reduced (mean preoperative value 13.8°; 7.8° postoperatively; $p<0.05$) after Scarf osteotomy. At follow-up however we noticed a recurrent deformity (mean value 10.7°; $p<0.05$).

Joint congruency of the first metatarsophalangeal (MTP) joint was calculated with the help of two lines referring to the base of the proximal phalanx and the estimated cartilage surface of the first metatarsal head. Preoperatively 133 feet (74.7%) presented with an incongruent first MTP joint, which was successfully realigned in 81 feet. The remaining 52 feet revealed a marked improvement, but postoperative MTP joint alignment was not ideal. At follow-up 29 of these feet (55.8%) presented with an impaired joint congruency ($p<0.05$) with a recurrent hallux valgus deformity.

Forty-five feet (25.3%) with a congruent joint preoperatively remained unchanged in 41 feet. Four feet developed an incongruent MTP joint, which was associated with a recurrent hallux valgus deformity.

It became evident that joint congruency was not achieved in 31.5%. Correlating the joint congruency with the hallux valgus angle it was obvious that hallux valgus recurrence was correlated to a malaligned MTP joint ($p<0.05$).

Hallux valgus interphalangeus (HVI) angle was measured regarding the axis of the proximal and the distal phalanx. One hundred forty-one feet (79.2%) with an isolated Scarf osteotomy presented with a mean preoperative HVI angle of 7.4°, which remained unchanged within

Table 2 Assessment of function according to the American Orthopaedic Foot and Ankle Society (AOFAS) score

Preoperative Activity limitation		Postoperative activity limitation			
		Severe limitation	Limitation	No limitation (daily activities)	No limitation
Severe limitation	16	0	6	10	0
Limitation	82	0	7	37	38
No limitation (daily activities)	69	0	0	33	36
No limitations	11	0	0	0	11
Footwear		Fashionable shoes, no insert	Comfortable shoes, insert	Modified shoes, brace	
Fashionable shoes, no insert	81	75	6	0	
Comfortable shoes, insert	92	63	29	0	
Modified shoes, brace	5	0	5	0	
ROM (MTP 1)		> 75 degrees	30–74 degrees	< 30 degrees	
> 75 degrees	88	45	33	0	
30–74 degrees	81	54	20	7	
< 30 degrees	9	0	5	4	
ROM (IP 1)		No restriction	Severe restriction		
No restriction	167	132	35		
Severe restriction	11	0	11		
MTP–IP stability		Stable	Unstable		
Stable	7	7	0		
Unstable	171	107	64		
Callus at MTP-IP		No callus	Symptomatic callus		
No callus	43	38	5		
Symptomatic callus	135	103	32		

ROM range of motion, *MTP* metatarsophalangeal joint, *IP* interphalangeal joint

the first three months. At the final radiographical assessment the HVI angle had increased significantly (mean value 9.7°; $p<0.05$). These results could not be correlated to any radiological or clinical findings.

In 37 feet (20.8%) with an HVI angle exceeding 10 degrees we performed an additional Akin osteotomy (mean preoperative angle 15.8°; 4.9° postoperatively; $p<0.001$). In these patients the HVI angle remained unchanged throughout the follow-up period.

Metatarsal alignment was calculated by the relationship of metatarsal length I / II: index plus: $1>2$; index plus/minus: $1=2$; index minus: $1<2$ (Table 6). In 43.8% of all feet Scarf osteotomy had led to a shortening of the metatarsal, which altered the metatarsal alignment. Further analysis illustrated no correlation to metatarsalgia or function at the fist MTP joint.

Table 3 Assessment of alignment according to the American Orthopaedic Foot and Ankle Society (AOFAS) score

Preoperative alignment		Postoperative alignment		
		Good	Fair, no symptoms	Poor
Good	0	0	0	0
Fair, no symptoms	22	19	7	0
Poor	156	101	55	0

Radiographic signs of arthritis (subchondral cysts, narrowing of the joint space and osteophytes) were evaluated. During the preoperative assessment 60 feet revealed early radiographic signs of arthritis. More than half of these patients (37 feet; 61.6%) showed a distinct worsening of the pre-existing degenerative joint lesions ($p<0.05$). In 118 feet the MTP 1 joint was assessed as normal. At follow-up 13 feet (11%) had developed distinct signs of arthritis.

We performed a linear regression analysis to evaluate the influence of pre-existing radiographic signs of arthritis at MTP 1 on the clinical outcome. In patients (118 feet) with a regular radiographic appearance of the MTP 1 joint the mean AOFAS score was 48.1 points preoperatively and 94.0 points at follow-up. The patients (60 feet) with pre-existing radiographic signs of MTP 1 joint arthritis displayed significantly ($p<0.05$) worse clinical results

Table 4 American Orthopaedic Foot and Ankle Society (AOFAS) forefoot score at preoperative assessment, three months after surgery and at the latest follow-up (44.9 months)

Assessment	Preoperative	Three months	44.9 months	*p*-values
Pain	17.9	37.0	36.8	$p<0.001$
Function	5.4	9.2	8.9	$p<0.001$
Shoe ware	5.8	8.8	8.6	$p<0.05$
ROM (MTP 1)	7.2	9.1	8.4	$p>0.05$[a]
ROM (IP 1)	4.9	4.8	3.5	$p<0.05$[a]
Stability (MTP 1)	1.9	5.5	4.9	$p<0.01$[a]
Calluses	1.3	3.2	5.4	$p<0.001$
Alignment	1.4	15.2	12.9	$p<0.001$[a]
Total	45.8	92.8	89.4	$p<0.01$

ROM range of motion, *MTP* metatarsophalangeal joint, *IP* interphalangeal joint

[a] During the follow-up period ROM at MTP 1 / IP 1, stability at MTP 1, and toe alignment worsened significantly ($p<0.05$)

(mean values: 42.7 points preoperatively, 83.3 points postoperatively).

Complications

Within the first six weeks after surgery we observed five delayed wound healings (2.8%) and five fractures (2.8%) of the first metatarsal. Three fractures occurred at the proximal end of the osteotomy; they healed uneventfully with a large callus formation, but some loss of correction. The remaining two fractures were located distally and obviously associated with a marked troughing (Fig. 2). These two patients underwent revision (hardware removal, internal fixation). Screw malposition and hardware overlength (3 feet, 1.7%) led to early hardware removal. This complication rate corresponds to that in the literature [18]. We observed no pseudarthrosis, algodystrophy, osteonecrosis or deep venous thrombosis.

At the final follow-up, 12 patients (6.7%) had undergone a reoperation. Due to symptomatic arthritic changes of the first metatarsophalangeal joint, MTP 1 arthrodesis was performed in three patients. The remaining nine patients presenting with recurrent hallux valgus deformity required another metatarsal osteotomy (two feet) or an arthrodesis of the first MC joint (seven feet).

Fig. 1 Follow-up of a 62-year-old woman presenting with an excellent correction over more than five years. **a** Preoperative radiograph indicating the metatarsus varus and hallux valgus deformity (first intermetatarsal angle 20 degrees, hallux valgus angle 35 degrees, subluxation of the first metatarsophalangeal joint). **b** Three months after the operation (first intermetatarsal angle 9 degrees, hallux valgus angle 0 degrees, congruent first metatarsophalangeal joint). **c** Sixty-one months after the operation (first intermetatarsal angle 9 degrees, hallux valgus angle 0 degrees, congruent first metatarsophalangeal joint)

Table 5 Time dependent changes in angular measurements of hallux valgus angle (HV), first intermetatarsal angle (IM 1), and hallux valgus interphalangeus angle (HVI)

Angular measurements	Preoperative	Three months	44.9 months	*p*-value
HV angle	39.0° (12°–76°)	12.5° (−10°–24°)	24.8 (−10°–39°)	$p<0.001$*
IM1 angle	13.8° (9°–21°)	8.8°(1°–14°)	10.7° (1°–17.4°)	$p<0.05$*
HVI angle	7.4° (0°–25°)	8.8° (0°–28°)	9.7° (6°–35°)	$p<0.05$*
HVI angle (Scarf+Akin)	15.8° (9°–36°)	5.4° (−3°–9°)	4.9° (−5°–8°)	$p<0.001$

* During the follow-up period HV angle, IM 1 angle and HVI angle worsened significantly ($p<0.05$)

Discussion

Referring to the AOFAS forefoot score, our results of the Scarf osteotomy were comparable to other studies [2, 7, 12, 16]. As reported by other authors, perioperative complication rate was low (4.5%) [12, 18].

The mean correction of hallux valgus angle (20.2°) and first intermetatarsal angle (4.1°) also corresponded to those in the literature [2, 7, 12, 16].

The most unexpected result of this study was that the radiological outcome of isolated Scarf osteotomies had worsened with time (Figs. 3a–c and 4a–c). Although a time-dependent loss of correction was often estimated for first metatarsal osteotomies, it had not been stated clearly for the Scarf osteotomy. Due to the design of our study we were able to elucidate some aspects that were critical for the outcome of the Scarf osteotomy.

Compared to the results we evaluated three months after surgery, we found that some radiographical findings (hallux valgus angle, hallux valgus interphalangeus angle, first intermetatarsal angle, MTP joint congruency) had worsened after a mean follow-up period of 44.9 months. Systematically reviewing these patients, we realised that the preoperative degree of HV deformity had a significant influence on the final clinical outcome. Patients with a HV angle exceeding 30 degrees preoperatively presented with worse results compared to patients with a HV angle less than 30 degrees. This correlation had only been mentioned once in the literature [12]. On the other hand the first IM angle did obviously not affect the final outcome.

Further assessment showed that joint congruency was also crucial for the outcome. Retrospectively we realised that most of those feet, which did not display a perfect joint congruency after three months, had developed a recurrent hallux valgus deformity at follow-up. Only 55% of the great toes were assessed as perfectly aligned. Discussing these results leads back to the surgical technique. Pivoting the first metatarsal head is required to correct the distal metatarsal articular angle and obtain a congruent joint. Due to the Z-shaped design of the osteotomy, rotating the distal fragment is technically demanding and requires shortening of the first metatarsal by removing bone wedges from the two transverse cuts. However this procedure will inevitably reduce the correction of the IM 1 angle, which is counter to the goals of treatment.

On the other hand the lateral release, which is essential in severe hallux valgus deformity with an incongruent joint, was probably not done adequately via the intraarticular approach. The inherent limitations of the transarticular approach have also been mentioned by other authors [21].

As a consequence we recommend limiting the indication for a classic Scarf osteotomy to patients with a normal distal metatarsal articular angle. In patients with a distinct lateral tilt of the metatarsal cartilage surface, alternative osteotomies (e.g. Chevron-type cut) should be taken into consideration to facilitate rotation of the distal metatarsal fragment [13].

Scarf osteotomy has been demonstrated to effectively restore a normal plantar pressure distribution [2]. In our patients metatarsalgia had improved in more than 70% of the affected feet. Nevertheless, 5% of patients complained of the onset of metatarsalgia after the operation. Critically

Table 6 Metatarsal alignment

Postoperative	Preoperative		
	Index minus 82	Index plus / minus 65	Index plus 31
Index minus	82	47 (72.3%)	2 (6.4%)
Index plus / minus		18 (27.7%)	29 (93.6%)

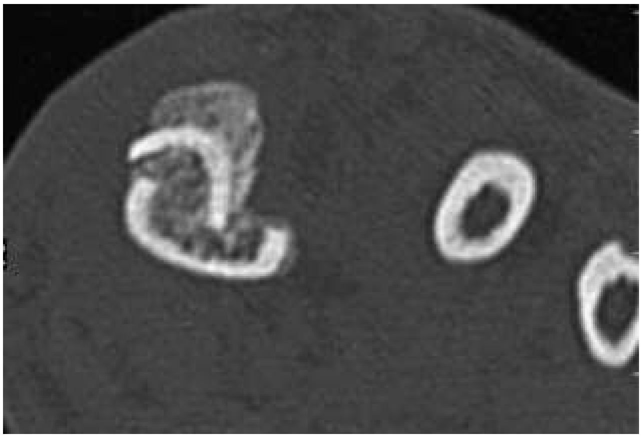


Fig. 2 CT scan of the distal (transversal plane) metatarsal clearly illustrating the troughing effect

reviewing these patients we considered elevation of the first metatarsal to be responsible for the metatarsalgia. Troughing of the two diaphyseal fragments has often been suggested to be critical in Scarf osteotomy [5]. On the other hand this is a well known problem even in distal metatarsal osteotomies [15]. In two patients suffering from a distal fracture we were able to clearly illustrate the troughing effect on CT scans (Fig. 1). While a huge amount of troughing (35%) was reported in a small series of patients [5], this complication was rare in our series as in other published series [18].

In 19% of our patients the pain level did not change or became worse after the operation. Retrospectively, 96% of these feet displayed a decreased range of motion at the first MTP joint, frequently corresponding to severe or moderate signs of arthritis on X-rays preoperatively. As mean reduction of metatarsal length (3.2 mm) did not differ from other studies [12] a decreased joint pressure could be expected even in these patients. However, 11% of our patients developed arthritic changes at the MTP joint postoperatively and more than 60% of those feet with pre-existing radiological signs of arthritis demonstrated a distinct worsening of degenerative changes. Since comparable results have been known even from open-wedge osteotomies of the cuneiform, the development of arthritis does not seem to be specific to metatarsal osteotomies [10].

The range of motion at the MTP 1 joint is considered to be a very important variable in assessing the postoperative outcome [17]. Nevertheless, we observed an impairment of joint function after Scarf osteotomy, which has also been mentioned by other authors [7, 14]. In conclusion, the metatarsal shortening alone is not sufficient to prevent arthritic changes at MTP 1 and to alleviate pain in patients

Fig. 3 Follow-up of a 57-year-old woman presenting with a recurrent deformity after 2.4 years. **a** Preoperative radiograph indicating the metatarsus varus and hallux valgus deformity (first intermetatarsal angle 19 degrees, hallux valgus angle 35 degrees, subluxation of the first metatarsophalangeal joint). **b** Three months after the operation (first intermetatarsal angle 7 degrees, hallux valgus angle 20 degrees, congruent first metatarsophalangeal joint). **c** Twenty-nine months after the operation (first intermetatarsal angle 13 degrees, hallux valgus angle 0 degrees, congruent first metatarsophalangeal joint)

Fig. 4 Follow-up of a 71-year-old woman presenting with a recurrent deformity after 4.9 years. **a** Preoperative radiograph indicating the metatarsus varus and hallux valgus deformity (first intermetatarsal angle 16 degrees, hallux valgus angle 38 degrees, subluxation of the first metatarsophalangeal joint). **b** Three months after the operation (first intermetatarsal angle 8 degrees, hallux valgus angle 5 degrees, congruent first metatarsophalangeal joint). **c** Fifty-nine months after the operation (first intermetatarsal angle 12 degrees, hallux valgus angle 20 degrees, incongruent first metatarsophalangeal joint)

with pre-existing arthritic changes at the first MTP joint. We therefore recommend that the Scarf osteotomy should be avoided in patients with pre-existing clinical and radiological signs of arthritis. Further shortening of the first metatarsal in combination with a phalangeal osteotomy will probably lead to a more successful outcome.

Range of motion at the MTP 1 joint worsened in more than 20% of our patients. This functional impairment after Scarf osteotomy has also been mentioned by other authors [7, 9]. However, the decreased range of motion does not seem typical of diaphyseal osteotomies, because this phenomenon has also been described for distal osteotomies [13, 14, 19].

From our clinical experience we did not anticipate that the isolated Scarf osteotomy had an influence on function and alignment of the first interphalangeal (IP) joint. In 14% of the feet presenting primarily with a normal range of motion at the first IP joint we noticed a significant reduction in joint function. These results did not reveal any correlation to the alignment of the first ray, the function at the MTP 1 joint or radiographic signs of arthritis at both joint levels. The radiographically assessed hallux valgus interphalangeus (HVI) angle, which remained unaffected within the first three months, developed a significant increase at the latest follow-up. The impaired joint function at the IP level may be attributed to the altered course of the extrinsic tendons attached at the base of the distal phalanx.

Critically assessing the results of our study we found various problems that were identified after thoroughly evaluating the clinical and radiological results. It was not surprising that the AOFAS scale did not reflect the outcome of hallux valgus surgery properly [22]. Radiological parameters should always be assessed to encompass all aspects.

In advising to the classical Scarf osteotomy we suggest a meticulous selection of patients.

Patients with obvious signs of arthritis do not respond well to the classical type of Scarf osteotomy with limited shortening of the metatarsal. Additional shortening osteotomy of the proximal phalanx or further shortening of the first metatarsal should be considered.

Subsequent enlargement of the HVI angle, which may result in an impingement of the second toe and impairs cosmetic appearance, should be routinely addressed with a phalangeal osteotomy.

As joint congruency has been evaluated to be crucial for the great toe alignment, the classical Scarf osteotomy should not be recommended in patients with an increased lateral tilt of the metatarsal articular surface. Alternate osteotomies, e.g. Chevron type osteotomy, are thought to be superior.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Allen DM, Nunley JA (2001) Measurement of the first/second intermetatarsal angle following proximal oblique metatarsal osteotomy. Foot Ankle Int 23:64–67
2. Aminian A, Kelikian A, Moen T (2006) Scarf osteotomy for hallux valgus deformity: an intermediate follow up of clinical and radiological outcomes. Foot Ankle Int 27:883–886
3. Barouk LS (2000) Scarf osteotomy for hallux valgus correction. Local anatomy, surgical technique, and combination with other forefoot procedures. Foot Ankle Clinics 5:525–558
4. Burutaran JM (1976) Hallux valgus y cortedad anatomica del primer metatarsano (correction quingica). Actual Med Chir Pied 13:261–266
5. Coetzee JC (2003) Scarf osteotomy for hallux valgus repair: the dark side. Foot Ankle Int 24:29–33
6. Coughlin MJ, Saltzman CL, Nunley JA (2002) Angular measurements in the evaluation of hallux valgus deformities: a report on the Ad Hoc Committee of the American Orthopaedic Foot & Ankle Society on angular measurements. Foot Ankle Int 23:68–74
7. Crevoisier X, Mouhsine E, Ortolano V, Udin B, Dutoit M (2001) The Scarf osteotomy for the treatment of hallux valgus deformity: a review of 84 cases. Foot Ankle Int 22:970–976
8. Dereymaeker G (2000) Scarf osteotomy for correction of hallux valgus. Surgical technique and results as compared to distal chevron osteotomy. Foot Ankle Clin 5:513–524
9. Jarde O, Trinquier-Lautard JL, Gabrion A, Ruzik JC, Vives P (1999) Hallux valgus treated by first metatarsal scarf osteotomy. A series of 50 cases with a minimum follow up of 2 years. Clin Orthop Reparatrice App Mot 85:374–380
10. Jawish R, Assoum H, Saliba E (2009) Opening wedge osteotomy of the first cuneiform for the treatment of hallux valgus. Int Orthop. doi:10.1007/s00264-009-0825-y
11. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley J, Myerson M, Sanders M (1984) Clinical rating system for the ankle-hindfoot, midfoot, hallux and lesser toes. Foot Ankle Int 15:349–353
12. Kristen KH, Berger C, Stelzig S, Thalhammer E, Posch M, Engel A (2002) The Scarf osteotomy for the correction of hallux valgus deformities. Foot Ankle Int 23:221–229
13. Lucijanic I, Bicanic G, Sonicki Z, Mirkovic M, Pecina M (2009) Treatment of hallux valgus with three-dimensional modification of Mitchell's osteotomy. Technique and results. J Am Podiatr Med Assoc 99:162–172
14. Magnan B, Bortolazzi R, Samaila E, Pezzè L, Rossi N, Bartolozzi P (2006) Percutaneous distal metatarsal osteotomy for correction of hallux valgus. J Bone Joint Surg [Am] 88:135–148
15. Nikolaou VS, Korres D, Xypnitos F, Lazarettos J, Lallos S, Sapkas G, Efstathopoulos N (2009) Fixation of Mitchell's osteotomy with bioabsorbable pins for treatment of hallux valgus deformity. Int Orthop 33:701–706
16. Perugia D, Basile A, Gensini A, Stopponi N, De Simeonibus AUM (2003) The Scarf osteotomy for severe hallux valgus. Int Orthop 27:103–106
17. Schneider W, Knahr K (2001) Surgery for hallux valgus. The expectations of patients and surgeons. Int Orthop 25:382–385
18. Smith AM, Alwan T, Davies MS (2003) Perioperative complications of the Scarf osteotomy. Foot Ankle Int 24:222–227
19. Schneider W, Knahr K (2002) Keller procedure and Chevron osteotomy in hallux valgus: five-year results of different surgical philosophies in comparable collectives. Foot Ankle Int 23:321–329
20. Schneider W, Csepan R, Knahr K (2003) Reproducibility of the radiographic metatarsophalangeal angle in hallux valgus surgery. J Bone Joint Surg [Am] 85:494–499
21. Stamatis ED, Huber MH, Myerson MS (2004) Transarticular distal soft-tissue release with an arthroscopic blade for hallux valgus correction. Foot Ankle Int 25:13–18
22. Thordarson D, Ebramzadeh E, Moorthy M, Lee J, Rudicel S (2005) Correlation of hallux valgus surgical outcome with AOFAS forefoot score and radiological parameters. Foot Ankle Int 26:122–127
23. Trnka HJ, Parks BG, Ivanic G, Chu IT, Easley ME, Schon LC, Myerson MS (2000) Six first metatarsal shaft osteotomies: mechanical and immobilization comparisons. Clin Orthop Rel Res 381:256–265

Foot Ankle Clin N Am
8 (2003) 15–35

Salvage of complications of hallux valgus surgery

Daniel E. Lehman, MD

OrthoIndy, 8450 Northwest Boulevard, Indianapolis, IN 46278, USA

The correction of hallux valgus deformities is one of the most commonly performed foot and ankle procedures. As with any procedure, there are complications which may arise following surgery. The rate of complications in hallux valgus surgery ranges from 10% to 55% [1]. Some of the complications are not amenable to corrective treatment. This article focuses on some of the more common complications that are seen in hallux valgus correction and their appropriate surgical and nonsurgical treatment.

Complications that are addressed in this article include recurrence of deformities, avascular necrosis, hallux varus, nonunion of metatarsal osteotomies, and malunion of metatarsal osteotomies. This paper also focuses on the more common surgical procedures, including proximal and distal chevron osteotomies, the Mitchell osteotomy, the Ludloff osteotomy, and the proximal crescentic osteotomy.

Recurrent deformity

One of the most apparent complications is recurrence of the hallux valgus deformity. The reported incidence of recurrence following hallux valgus surgery was reported to be as high as 16% [2–11]. A preoperative evaluation to ensure that the chosen procedure has enough corrective ability to address and correct the patient's deformity most appropriately prevents this complication. The use of a particular osteotomy is based upon the preoperative measurement of the intermetatarsal (IM) angle, hallux valgus angle, and distal metatarsal articular angle (DMAA). The congruence of the first metatarsophalangeal (MTP) joint should also be evaluated. Determination of the joint congruence can be difficult.

Initially, the distal chevron osteotomy was indicated for an intermetatarsal angle of $< 15°$ and a hallux valgus angle of $< 35°$. This was also recommended for a congruent joint. More recent articles recommended the distal chevron for an

E-mail address: dlehman@orthoindy.com

PII: S1083-7515(02)00130-4

intermetatarsal angle of $\leq 12°$ and a hallux valgus angle of $\leq 30°$ [5,10,12]. The Mitchell osteotomy is better able to correct a more severe deformity and is generally used for an intermetatarsal angle of $\leq 15°$ to 18° and a hallux valgus angle of $\leq 35°$ to 40° [5,12].

If the intermetatarsal angle is $\geq 12°$ and the hallux valgus angle is $\geq 30°$, then a more proximal osteotomy is generally used. This may include the proximal chevron, proximal crescentic, or Ludloff osteotomy. Because the osteotomy is performed more proximally, the potential correction of the angular deformity is greater. Unfortunately, the more proximal location also increases the risk of malunion of the osteotomy, particularly with regard to the issues of shortening and dorsal angulation.

When a patient presents with a recurrent hallux valgus deformity, it is helpful to assess the preoperative radiographs to determine if the recurrence was the result of the choice of a procedure that was not strong enough to correct the deformity. Other issues that should be investigated include the presence of hypermobility of the medial cuneiform–first metatarsal joint, as well as an assessment of the distal metatarsal articular angle.

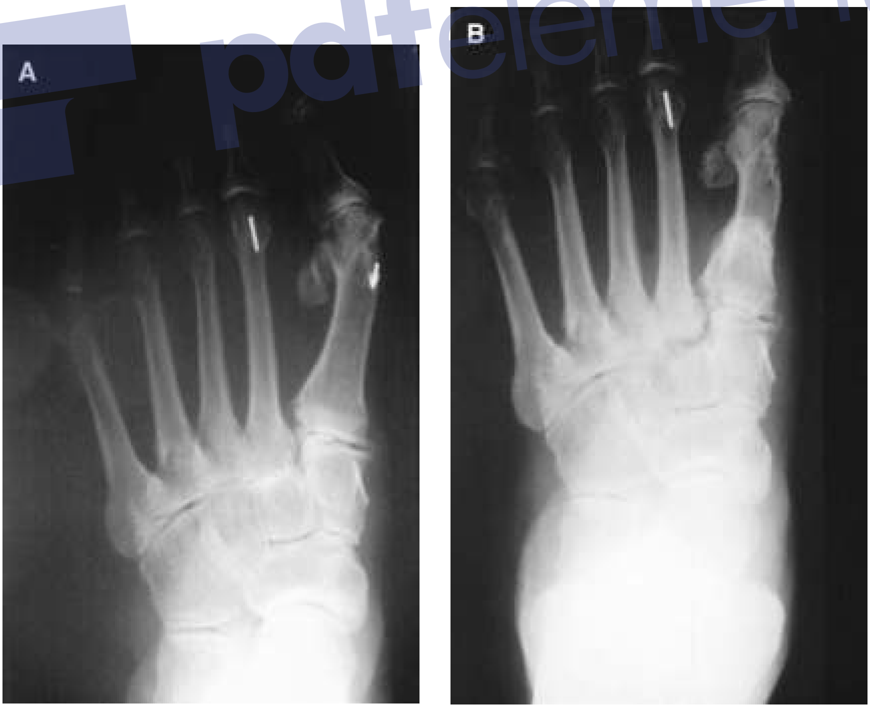


Fig. 1. (A) 65-year-old male with symptomatic recurrent hallux valgus deformity 4 years following surgical correction. (B) Postoperative radiograph following proximal chevron osteotomy and distal capsular soft-tissue reconstruction. Patient is asymptomatic.

If the recurrence of the deformity is asymptomatic, the patient is best advised to simply observe the foot as the likelihood of successful revision is reduced [13]. If symptoms are present that are due to the recurrent deformity, than a revision surgery may be considered. Before performing surgery, it is imperative to determine why the initial surgery was not successful to reduce the risk of a second recurrence.

The subsequent deformity must then be evaluated as is done with a primary hallux valgus deformity. Unique issues that must be considered include the adequacy of the medial soft tissues, the adequacy of the medial eminence resection, and the status of the first MTP joint. Radiographically, the intermetatarsal, hallux valgus angle, and distal metatarsal articular angles must be evaluated (Fig. 1).

Surgical treatment should be undertaken using the same guidelines for correction of a primary hallux valgus deformity. Because of the influence of the DMAA in recurrence, it may be necessary to perform either a double metatarsal osteotomy to correct the DMAA or to use an Akin osteotomy of the proximal phalanx to create a more normal appearing foot. The Akin osteotomy does not realign the tendon orientation around the first MTP joint and should rarely be used alone to correct a recurrent deformity. Sammarco and Idusuyi [14] recommended the routine use of a proximal osteotomy even in those patients whose IM angle was $< 15°$.

Avascular necrosis

Avascular necrosis (AVN) of the first metatarsal head is a condition that primarily arises as a result of distal metatarsal osteotomies. This has primarily been described following the distal chevron osteotomy; the incidence of avascular necrosis is variable and ranges from 0% to 76% [15–22].

Traditionally it was believed that the incidence of AVN was influenced by the use of a second incision over the first intermetatarsal space to release the adductor tendon and lateral capsule. Shereff et al [23] demonstrated that the blood supply to the distal first metatarsal is through the dorsal lateral artery which enters the first metatarsal through the dorsolateral aspect of the first metatarsal. This artery is at risk with an incision placed in the first intermetatarsal space. The arterial network around the first metatarsal is also at risk with penetration of the lateral cortex of the first metatarsal by the saw blade at the time of the osteotomy. Additionally, Jones et al [24] defined a safe zone for performance of the distal chevron osteotomy which is associated with a reduced risk of AVN (Fig. 2).

Several investigators demonstrated a low incidence of avascular necrosis with the use of a second lateral incision. This incidence has ranged from less than 2% [18] to 40% [17]. An alternative to the use of a second incision is a release of the lateral capsule and adductor tendon through the joint [25].

Avascular necrosis of the first metatarsal head can also occur following a Mitchell osteotomy, although this is less common. The highest incidence of AVN following a Mitchell osteotomy is 2.5% [26].

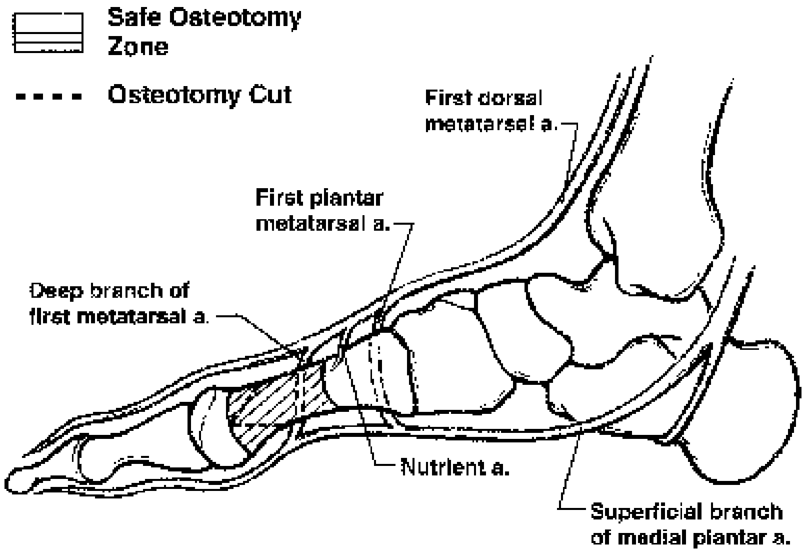


Fig. 2. Relationship between first metatarsal arterial supply and chevron osteotomy exit sites. Safe zone is outline in cross hatch. (*From* Jones KA, Feiwell LA, Freedman EL, et al. The effect of chevron osteotomy with lateral capsular release on the blood supply to the first metatarsal head. J Bone Joint Surg 1995;77A:197–204; with permission.)

Following a distal chevron osteotomy, transient radiographic changes may be seen in the first metatarsal head. Typically, these are not significantly symptomatic and may resolve. Rarely, the patient may develop complete avascular necrosis of the first metatarsal. Even in this situation, the patient may be asymptomatic. In those patients who are symptomatic, nonoperative treatment can be undertaken with the use of a full-length foot orthosis with a Morton's extension under the great toe. This serves to splint the toe and reduce the amount of stress that is applied across the first MTP joint.

Various procedures were described to alleviate more pronounced symptoms. For less severe cases, a synovectomy of the first MTP joint, possibly combined with subchondral drilling, is an option. More severe cases may require either a resection arthroplasty, such as a Keller procedure or a first MTP fusion. If arthrodesis is undertaken, it may be necessary to use an interpositional bone graft to maintain the length of the first ray while adequately removing the avascular bone. The length of time to bone consolidation is typically increased in these patients.

Hallux varus

Hallux varus may develop after correction for hallux valgus. This more commonly occurs following a proximal metatarsal osteotomy than after a distal chevron osteotomy. The incidence rate of hallux varus following a proximal metatarsal osteotomy was reported to be as high as 10% to 12% [6,27–30]. Most patients with hallux varus are asymptomatic, especially if the hallux varus measures $<10°$ [51] and, therefore, do not necessarily require treatment [5].

Each case of hallux varus must be carefully evaluated to determine the exact etiology. Hallux varus can arise simply because of overplication of the medial capsule. It may also be seen as a result of excessive resection of the medial eminence or following excision of the lateral sesamoid. Patients are also at an increased risk of hallux varus if a negative intermetatarsal angle has been created by shifting the distal fragment of the metatarsal too far laterally when performing a proximal metatarsal osteotomy.

As discussed earlier, most patients with hallux varus are asymptomatic. If pain occurs, it may be due to either the subluxation of first MTP joint leading to an alteration of the first MTP joint mechanics or to difficulty with shoewear. With long-standing deformities, arthritis of the first MTP joint may develop. This limits the options for salvage.

A large number of salvage operations have been described in the literature. Most of these have been performed only in small series [31]. In general, these procedures can be grouped into soft-tissue releases, tendon transfers, arthroplasty, or arthrodesis. It may be necessary to combine two or more procedures depending upon the nature of the deformity (Fig. 3).

Before proceeding with correction of the hallux varus deformity, one must determine whether the deformity is purely due to medial angulation at the first MTP joint or whether a component of clawing is also present. In most instances, correction of the deformity will include a lengthening of the medial capsule. If there is a significant clawtoe deformity, than a lengthening of the extensor hallucis longus tendon may also be necessary. Johnson and Spiegl [32] described an extensor hallucis tendon transfer deep to the transverse metatarsal ligament that is combined with an interphalangeal arthrodesis. In their report of 15 patients, all patients who were followed were satisfied. Skalley and Myerson [33] reported that more than 40% of their patients complained of first MTP joint stiffness after a similar procedure. For this reason, Myerson et al [34,35] reported on a transfer of the extensor hallucis brevis that reduces first MTP stiffness (Fig. 4).

For the elderly patient, a Keller arthroplasty is a relatively simple solution. The excision of the base of the proximal phalanx decompresses the joint and allows for correction of the hallux varus deformity. This is also a good option for patients with significant first MTP arthritis.

In the younger patient with arthritis, a first MTP arthrodesis is a predictable means of addressing the deformity and the pain from arthritis. This is also helpful for those patients who have excessive resection of the medial eminence with subsequent joint arthrosis (Fig. 5).

Nonunion of osteotomies

Nonunion of osteotomies is rare in hallux valgus surgery. Most procedures are performed through metaphyseal bone which usually heals predictably following

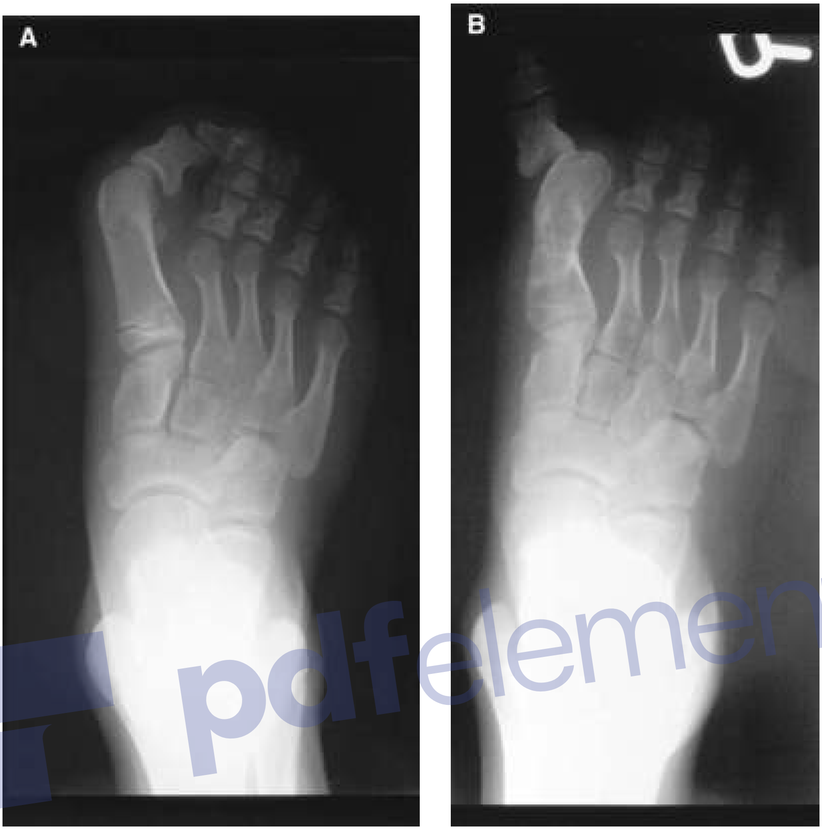


Fig. 3. (A) Preoperative radiograph of 13-year-old female with symptomatic hallux valgus. (B) Radiograph taken 6 months postoperatively showing hallux varus. Patient is having difficulty with shoewear. (C) Following hallux varus correction with soft tissue realignment and distal metatarsal osteotomy, alignment is improved.

surgery. Additionally, modern fixation techniques allow for more rigid fixation following surgery. This also reduces the risk of nonunion.

The reported risk of nonunion following metatarsal osteotomy varies. Following a distal chevron osteotomy, nonunion is rarely reported but can occur. The occurrence of nonunion following a Ludloff osteotomy is also rarely reported [7]. With the use of a Mitchell osteotomy, the risk of nonunion is also rarely seen although O'Malley et al [36] described the treatment of three patients who developed a nonunion following a Mitchell osteotomy. Similarly, the more proximal osteotomies also have a low incidence of nonunion.

Prevention of nonunion is influenced by surgical technique and postoperative immobilization. Chevron osteotomies should subtend an angle of $< 70°$ as an increased angle will reduce the stability of the osteotomy and may increase the risk of nonunion [37–39]. Because of the inherent stability of the chevron

Fig. 3 (*continued*).

osteotomy, the use of fixation with this procedure has been a subject of debate. Theoretically, the use of fixation should decrease the risk of nonunion. Because of the low incidence of nonunion, this has not been demonstrated in studies to date [40,41]. The chevron osteotomy also allows for a more aggressive post-operative weightbearing protocol using a wooden-soled shoe.

The Mitchell osteotomy is significantly less stable than the chevron osteotomy. Consequently, it is associated with an increased risk of nonunion. To reduce the risk of nonunion and loss of position, a variety of modifications to the Mitchell osteotomy were described, including the use of k-wires, Herbert screws, and interfragmentary screws [42–45].

More proximal metatarsal osteotomies also have an increased risk of nonunion and malunion. This is related to the increased lever arm of the first metatarsal which increases the stress being applied to the osteotomy site. The chevron osteotomy was shown to have a greater intrinsic stability as demonstrated by a higher load to failure [28,46]. Again, the incidence of nonunion is low enough

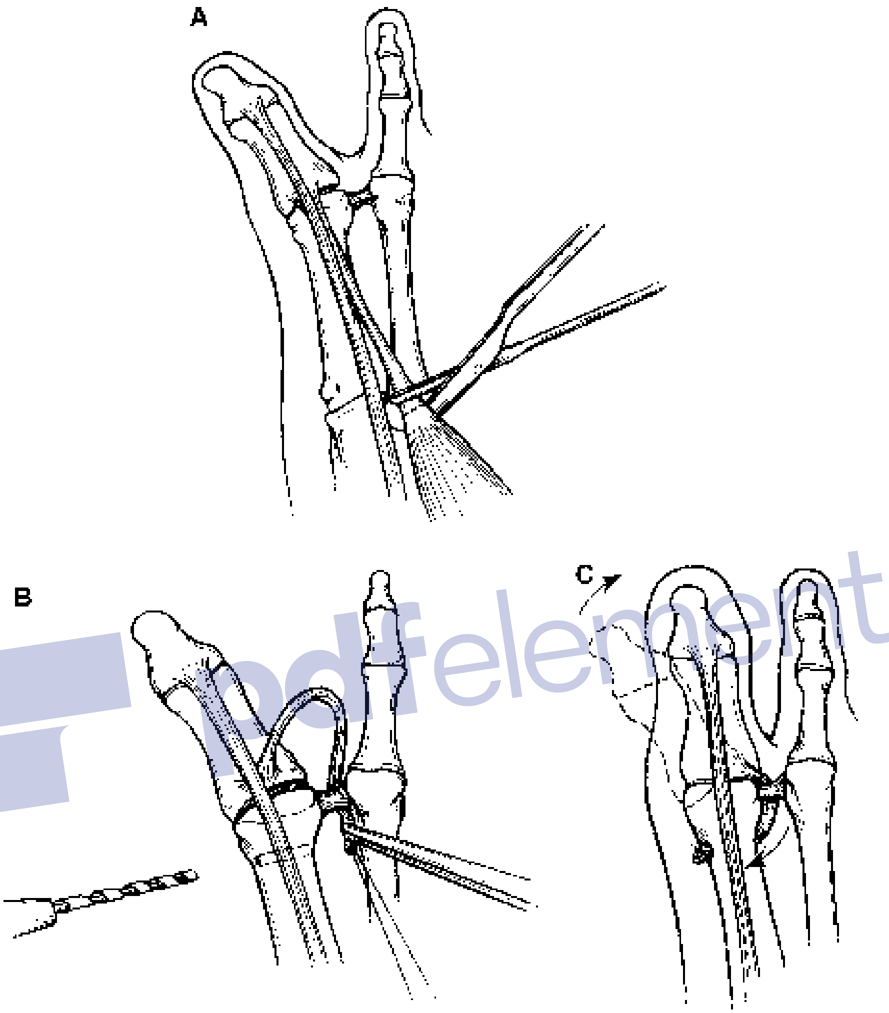


Fig. 4. (A) Extensor hallucis brevis tendon is divided at musculotendinous junction. (B) Distal stump of extensor hallucis brevis tendon is routed deep to transverse metatarsal ligament. A drill hole is made transversely through the distal first metatarsal. (C) Extensor hallucis brevis is passed through drill hole and sewn into medial soft tissues. (*From* Juliano PJ, Myerson MS, Cunningham BW. Biomechanical assessment of a new tenodesis for correction of hallux varus. Foot Ankle Intl 1996;17:17–20; with permission.)

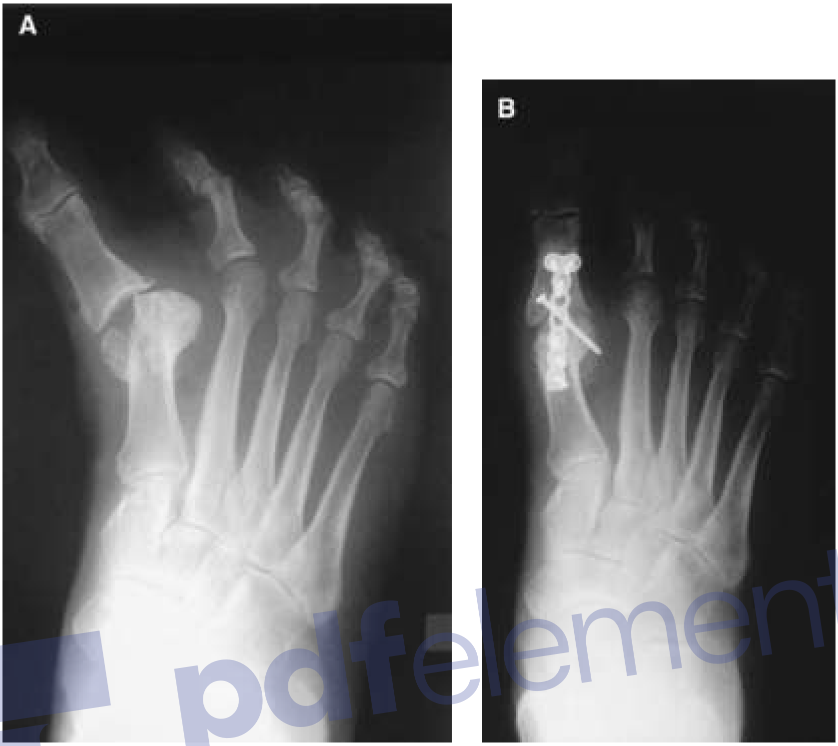


Fig. 5. (A) Postoperative radiograph of 67-year-old female following hallux valgus correction and attempt to correct postoperative hallux varus. (B) Radiograph following successful first MTP arthrodesis.

that it is difficult to demonstrate a clinically significant difference in the rate of nonunion when comparing the proximal metatarsal osteotomies. The Ludluff osteotomy was recently shown to be more stable than either a proximal chevron or crescentic osteotomy [47].

Nonunion, although rarely encountered, is usually symptomatic. The patient will present with complaints of pain and possibly persistent swelling. The pain is usually worse when the patient is on their feet.

Conservative treatment options are limited. The use of a rigid, rocker bottom shoe modification or a Morton's extension could be considered although this is unlikely to provide adequate pain relief. An external electrical bone stimulator can be used in an attempt to accomplish union if revision surgery is not immediately desired. Typically, the nonunited osteotomy must be addressed surgically.

Surgical treatment includes debridement of the nonunion site, the placement of autogenous bone graft, and fixation. Bone graft can usually be harvested from the distal tibial metaphysis which eliminates the need for an iliac crest graft (Fig. 6).

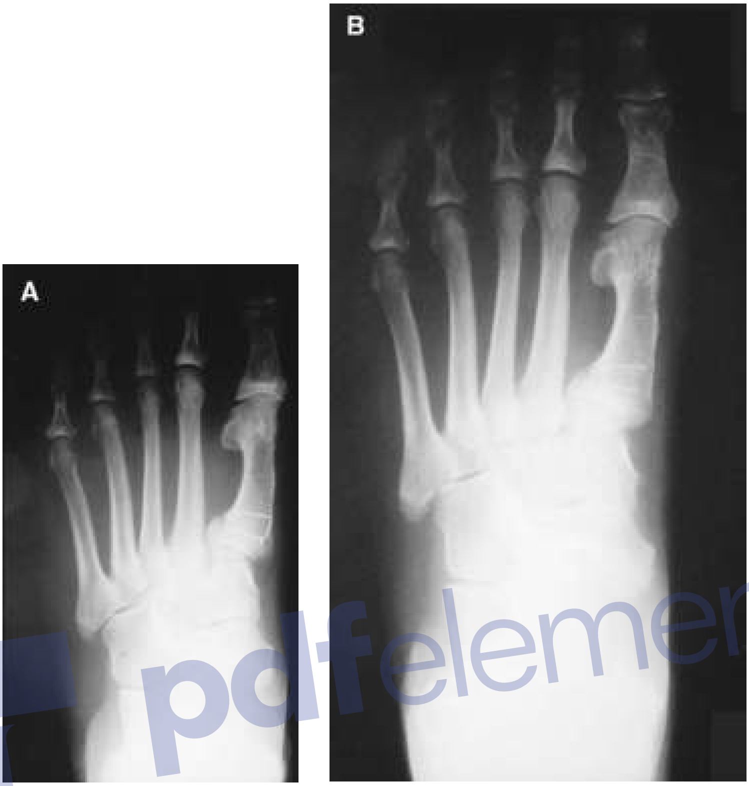


Fig. 6. (A) Incomplete union 3 years following proximal metatarsal osteotomy. (B) Postoperative radiograph showing successful consolidation with use of distal tibial bone graft.

If there has been significant erosion, a tricortical graft from the iliac crest is used to provide structural integrity. Fixation may be accomplished either with k-wires, screw fixation, or a plate depending upon the location and geometry of the nonunion. Following treatment for a nonunion, the patient is nonweightbearing for approximately 6 weeks before advancing weightbearing.

Metatarsal malunion

The concept of metatarsal malunion includes two primary deformities, shortening and dorsal malunions of the distal fragment. All metatarsal osteotomies are associated with some degree of shortening. The extent of shortening is dependent upon the type of osteotomy. The distal chevron osteotomy is associated with minimal shortening. Some studies showed shortening that ranged up to 6 mm; however, most studies showing shortening of 2.0 to 2.5 mm [16,17,48–53].

Proximal metatarsal osteotomies are similarly associated with relatively small amounts of shortening. Studies did not show any significant differences with regards to shortening when comparing the proximal chevron osteotomy and the crescentic osteotomy. Both osteotomies are associated with shortening of 2.0 to 2.5 mm [6,27,28,54]. The Ludluff osteotomy was reported to have an average shortening of 1.7 mm [7].

The Mitchell osteotomy is associated with the greatest degree of shortening. This osteotomy is associated with shortening of 3 to 7 mm [8,42,45,55]. One of the major preoperative contraindications to the Mitchell osteotomy is patients in whom there is excessive shortening of the first metatarsal in relation to the second metatarsal.

A shortened first metatarsal is generally associated with transfer metatarsalgia. This is usually seen under the second metatarsal although it can also effect the lateral metatarsal heads as well. When shortening is seen, the possibility of a dorsal malunion must also be evaluated.

Shortening of the first metatarsal can be treated with a foot orthosis. This should be a full length orthosis which includes a metatarsal pad and stress relief under the affected metatarsal head. A Morton's extension also helps to increase the weightbearing capacity of the medial side of the foot.

If the patient continues to demonstrate symptoms that are not responsive to conservative treatment, then a lengthening procedure becomes an option. Lengthening may be done either in one stage or by distraction osteogenesis using a mini-external fixator. Lengthening is associated with increased stiffness of the first MTP joint. Lengthening also causes the dorsal skin to become taut for closure. For these reasons, lengthening should be undertaken only if the symptoms are not amenable to conservative treatment.

Single-stage lengthening is generally done using a tricortical bone graft. This may be performed with either an allograft or an autograft. Iliac crest graft is generally of an appropriate contour for lengthening of the first metatarsal. The metatarsal is best lengthened in the metaphyseal region. Fixation is obtained using either a dorsal plate or screw fixation. The author prefers to contour a Synthes modular hand plate over the dorsal surface of the metatarsal. Following the procedure, immobilization is maintained in a short leg cast until consolidation is obtained. It has been the author's practice to maintain the patient nonweight bearing until the graft is consolidating at the proximal and distal interfaces (Fig. 7).

Lengthening may also be done using a distraction osteogenesis technique. This type of lengthening is better used for more severe defects, as a greater amount of length may be obtained. Both techniques are associated with a tendency to increase stiffness in the first MTP joint; for this reason vigorous postoperative therapy is required to maximize the range of motion of the first MTP joint. Stiffness seems to be more of an issue in patients in whom a single stage lengthening was performed [56].

If the patient is experiencing symptoms that are caused by a transfer lesion isolated to a single lesser metatarsal, the problem can be addressed by a

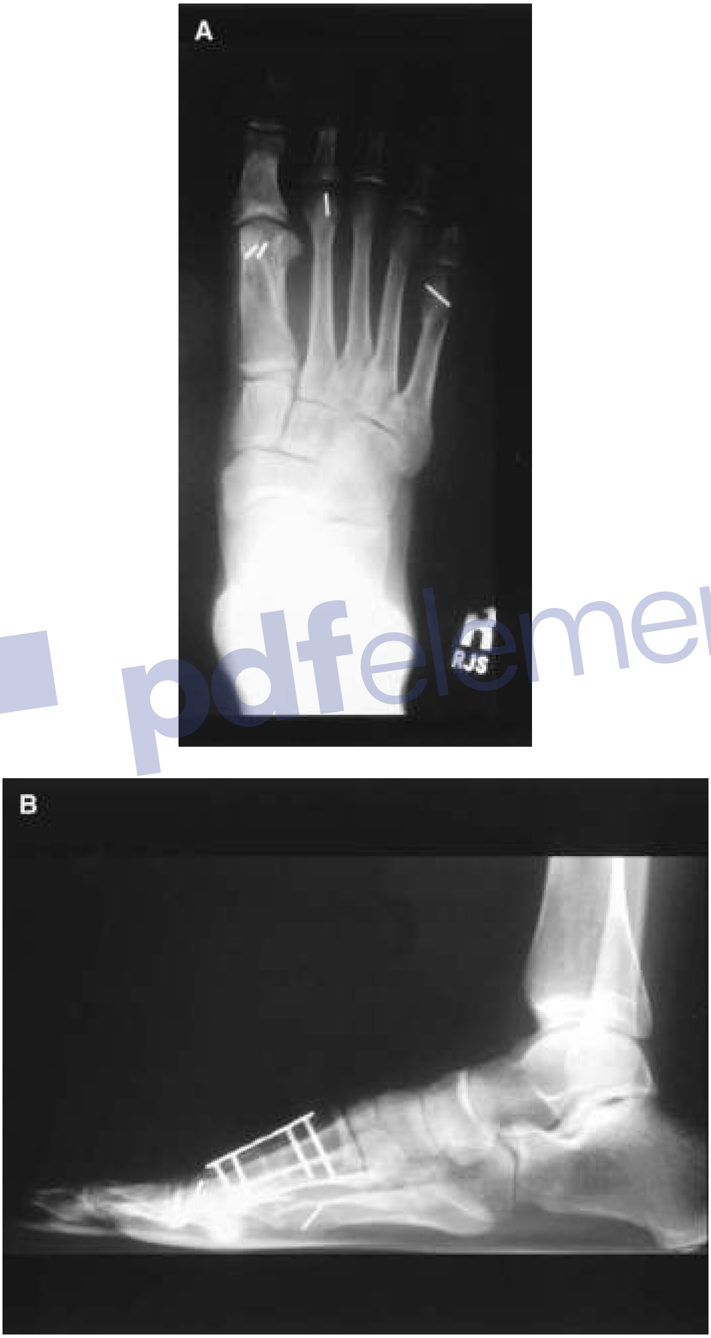

A
RJS
B

Fig. 7. (A) Shortened first metatarsal following distal chevron osteotomy. (B) Postoperative radiograph following single stage lengthening with tricortical iliac crest bone graft and dorsal plate fixation. (C) A/P radiograph following plate removal.

dorsiflexion ostetomy of the lesser metatarsal. In performing this, it is important to ensure that the adjacent metatarsals will not become prominent after the osteotomy as a result of simply transferring the lesion laterally. A shortening or dorsiflexion osteotomy of the second metatarsal is most helpful for treatment of transfer lesions under the second metatarsal in patients with a long second metatarsal (Fig. 8).

Malunion of the first metatarsal may also include a dorsal malunion. This may be seen with any type of metatarsal osteotomy, but is most commonly reported

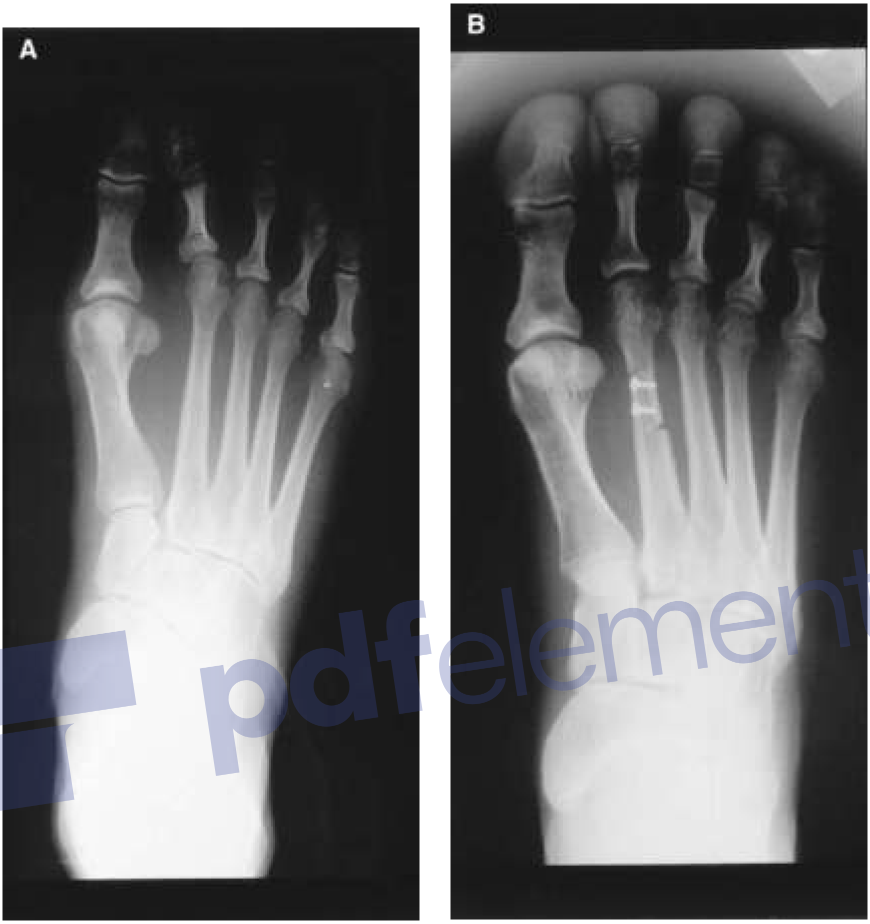


Fig. 8. (A) Patient with painful callous under second metatarsal head following hallux valgus correction. (B) Treatment with shortening osteotomy of the second metatarsal.

with a crescentic osteotomy. A dorsal malunion may arise as a result of a variety of factors. One factor is improper orientation of the osteotomy. If the osteotomy is aligned in a dorsiflexed position, this will result in a dorsal malunion. The geometry of the first metatarsal is easily malpositioned. When making a cut for an osteotomy, it is imperative that care is taken to ensure that the osteotomy is made in a plane that is perpendicular to the long axis of the first metatarsal. The saw blade should be oriented in a perpendicular or even a slightly plantar direction as a cut is made from the medial side to the lateral side. This will result in at least no dorsiflexion or even a little plantarflexion as the distal fragment is angulated laterally.

Fig. 9. (A) Recurrent hallux valgus deformity associated with painful second hammertoe. (B) Lateral radiograph demonstrating dorsiflexed first metatarsal. (C,D) Treatment with interpositional iliac crest graft combined with closing wedge distal chevron osteotomy. Second toe was treated with a fusion of the Proximal Interphalangeal Joint (PIP) joint.

A dorsal malunion may also arise if the osteotomy surfaces are not congruent. This can occur if the saw blade is not of a sufficient length to complete the cut through the metatarsal. If the blade is too short, the bone will crack on the far cortex. This can lead to a spike of bone that can impede congruency of the bony surfaces as fixation is attempted. More importantly, if the osteotomy is not securely fixed, or if there is a loss of fixation because of fracture, then a dorsal malunion may occur. Several investigators documented the development of a

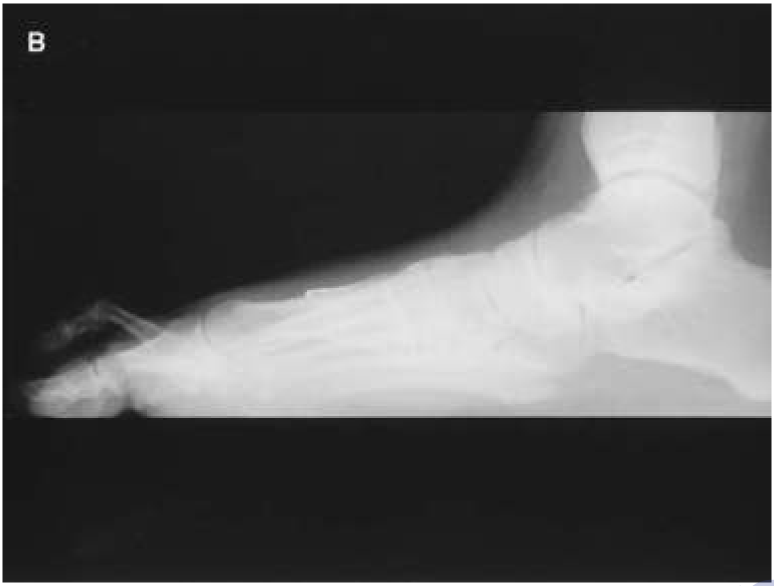


Fig. 9 (*continued*).

dorsal malunion on a delayed basis despite solid fixation and appropriate alignment of the osteotomy [5,57]. This is most commonly seen with a crescentic osteotomy. For this reason, careful protection of the osteotomy should be undertaken until healing has occurred.

Patients with a dorsiflexion malunion will typically complain of pain that is caused by the transferring of pressure under the adjacent metatarsals. This is usually associated with the development of a transfer lesion under the lesser metatarsal heads. Initial treatment of this should be conservative. This is best addressed with a full-length foot orthosis that includes a metatarsal pad to decrease the pressure being applied under the affected metatarsal heads.

If the patient does not respond to conservative treatment, then surgical correction can be undertaken. Surgical treatment is similar to that used for a shortened metatarsal and includes a corrective osteotomy at the site of the dorsal angulation. This can be accomplished with a crescentic saw blade with rotation of the distal fragment to bring the first metatarsal head in line with the adjacent metatarsal heads. If there is any significant shortening, then the osteotomy is performed with an interpositional bone graft that is wedged to correct the dorsal malunion. The bone graft can be either allograft or autograft. As with osteotomies

Fig. 9 (*continued*).

for correction of shortening, it is imperative to minimize weightbearing until the graft has consolidated (Fig. 9).

Summary

Complications following hallux valgus surgery can occur and are a frequent source of patient dissatisfaction. The treatment of these complications begins with careful preoperative planning to ensure that the chosen procedure is

Fig. 9 (*continued*).

appropriate for the specific patient. When complications occur, treatment must also be individualized to address the symptoms of the patient. This article presented an overview of the more common complications that are seen following hallux valgus surgery. Nonsurgical and surgical options for treatment were outlined to assist in the management of these complications.

Acknowledgements

The author would like to acknowledge Melanie Sanders, MD for assisting with examples that were used in this paper.

References

[1] Scioli MW. Complications of hallux valgus surgery and subsequent treatment options. Foot Ankle Clin 1997;2:719–39.
[2] Austin DW, Leventen EO. A new osteotomy for hallux valgus. Clin Orthop 1981;157:25–30.
[3] Hawkins FB, Mitchell CL, Hedrick DW. Correction of hallux valgus by metatarsal osteotomy. J Bone Joint Surg 1945;27A:387–94.
[4] Lewis RJ, Feffer HL. Modified chevron osteotomy of the first metatarsal. Clin Orthop 1981;157:105–9.

[5] Mann RA, Coughlin MJ. Adult hallux valgus. In: Mann RA, Coughlin MJ, editors. Surgery of the Foot and Ankle. 6th edition. St. Louis: Mosby; 1993. p. 167–296.
[6] Mann RA, Rudicel S, Graves SC. Repair of hallux valgus with a distal soft tissue procedure and proximal metatarsal osteotomy. J Bone Joint Surg 1992;74A:124–9.
[7] McKibbin WK, Stein RE, Hall RL, et al. The proximal oblique metatarsal osteotomy for the treatment of hallux valgus. Presented at 14th Annual AOFAS Summer Meeting. Boston, July 24, 1998.
[8] Merkel KD, Katch YI, Johnson EW, et al. Mitchell osteotomy for hallux valgus: long term follow-up and gait analysis. Foot Ankle 1983;3:189–96.
[9] Mitchell CL, Fleming JL, Allen R, et al. Osteotomy-bunionectomy for hallux valgus. J Bone Joint Surg 1958;40A:41–60.
[10] Veri JP, Pirani SP, Claridge R. Crescentic proximal metatarsal osteotomy for moderate to severe hallux valgus: a mean 12.2 year follow-up study. Foot Ankle Int 2001;22:817–22.
[11] Weinfeld SB. The Ludloff osteotomy for correction of hallux valgus: results of 31 cases by one surgeon. Presented at 31st Annual AOFAS Specialty Day. San Francisco, March 3, 2001.
[12] Coughlin MJ. Hallux valgus. J Bone Joint Surg 1996;78A:932–66.
[13] Kitaoka HB, Patzer GL. Salvage treatment of failed hallux valgus operations with proximal metatarsal osteotomy and distal soft-tissue reconstruction. Foot Ankle Int 1998;19:127–31.
[14] Sammarco GJ, Idusuyi OB. Complications after surgery of the hallux. Clin Orthop 2001;391: 59–71.
[15] Horne G, Tanzed T, Ford M. Chevron osteotomy for the treatment of hallux valgus. Clin Orthop 1984;183:32–6.
[16] Mann RA, Donatto KC. The chevron osteotomy: a clinical and radiographic analysis. Foot Ankle Int 1997;18:255–61.
[17] Meier PJ, Kenzora JE. The risks and benefits of distal first metatarsal osteotomies. Foot Ankle 1985;6:7–17.
[18] Pochatko DJ, Schlehr FJ, Murphy MD, et al. Distal chevron osteotomy with lateral release for treatment of hallux valgus deformity. Foot Ankle Int 1994;15:457–61.
[19] Rossi WR, Ferreira JCA. Chevron osteotomy for hallux valgus. Foot Ankle 1992;13:378–81.
[20] Thomas RL, Espinosa FJ, Richardson EG. Radiographic changes in the first metatarsal head after distal chevron osteotomy combined with lateral release through a plantar approach. Foot Ankle Int 1994;15:285–92.
[21] Trnka HJ, Zembsch A, Easley ME, et al. The chevron osteotomy for correction of hallux valgus. Comparison of findings after two and five years of follow-up. J Bone Joint Surg 2000;82A: 1373–8.
[22] Trnka HJ, Zembsch A, Wiesauer H, et al. Modified Austin procedure for correction of hallux valgus. Foot Ankle Int 1997;18:119–27.
[23] Shereff MJ, Yang QM, Kummer FJ. Extraosseous and intraosseous arterial supply to the first metatarsal and metatarsophalangeal joint. Foot Ankle 1987;8:81–93.
[24] Jones KJ, Feiwell LA, Freedman EL, et al. The effect of chevron osteotomy with lateral capsular release on the blood supply to the first metatarsal head. J Bone Joint Surg 1995;77A:197–204.
[25] Johnson JE, Clanton TO, Baxter DE, et al. Comparison of chevron osteotomy and modified McBride bunionectomy for correction of mild to moderate hallux valgus deformity. Foot Ankle 1991;12:61–8.
[26] Blum JL. The modified Mitchell osteotomy-bunionectomy: indications and technical considerations. Foot Ankle 1994;15:103–6.
[27] Brodsky JW, Beischer A, Robinson A, et al. Hallux valgus correction with modified McBride bunionectomy and proximal crescentic osteotomy: clinical, radiological and pedobarographic outcome. Presented at 31st AOFAS Winter Meeting Specialty Day. San Francisco, March 3, 2001.
[28] Easley ME, Kiebzak GM, Davis WH, et al. Prospective, randomized comparison of proximal crescentic and proximal chevron osteotomies for correction of hallux valgus deformity. Foot Ankle Int 1996;17:307–16.

[29] Hetherington VJ, Syeinbock G, LaPorta D, et al. The Austin bunionectomy: a follow-up study. J Foot Ankle Surg 1993;32:162–6.
[30] Thordarson DB, Leventeen EO. Hallux valgus correction with proximal metatarsal osteotomy: two-year follow-up. Foot Ankle 1992;13:321–6.
[31] Sander M. Complications of hallux valgus surgery. Iatrogenic hallux varus, soft tissue reconstruction. Foot Ankle Clin 1998;3:1–18.
[32] Johnson KA, Spiegl PV. Extensor hllucis longus transfer for hallux varus deformity. J Bone Joint Surg 1984;66A:681–6.
[33] Skalley TC, Myerson MS. The operative treatment of acquired hallux varus. Clin Orthop 1994;306:183–91.
[34] Juliano PJ, Myerson MS, Cunningham BW. Biomechanical assessment of a new tenodesis for correction of hallux varus. Foot Ankle Int 1996;17:17–20.
[35] Myerson MS, Komenda GA. Result of hallux varus correction using an extensor hallucis brevis tenodesis. Foot Ankle 1996;17:21–7.
[36] O'Malley MJ, Chao W, Thompson FM. Treatment of established nonunions of Mitchell osteotomies. Foot Ankle Int 1997;18:77–80.
[37] Donnelly RE, Saltsman CL, Kile TA, et al. Modified chevron osteotomy for hallux valgus. Foot Ankle Int 1994;15:642–5.
[38] Hanft JR, Kashuk KB, Bonner AC, et al. Rigid internal fixation of the Austin/chevron osteotomy with Herbert screw fixation: a retrospective study. J Foot Surg 1992;31:512–8.
[39] Kissel CG, Unroe BJ, Parker RM. The offset "v" bunionectomy using cortical screw and buried Kirschner wire fixation. J Foot Surg 1992;31:560–77.
[40] Crosby LA, Bozarth GR. Fixation comparison for chevron osteotomies. Foot Ankle Int 1998;19:41–3.
[41] McCluskey LC, Johnson JE, Wynarsky GT, et al. Comparison of stability of proximal crescentic metatarsal osteotomy and proximal horizontal "v" osteotomy. Foot Ankle 1994;15:263–70.
[42] Briggs TWR, Smith P, McAuliffe TB. Mitchell's osteotomy using internal fixation and early mobilization. J Bone Joint Surg 1992;74B:137–9.
[43] Downing ND, Radford PJ. Stabilization of the Mitchell first metatarsal osteotomy using an intramedullary k-wire. Foot Ankle Int 1999;20:301–2.
[44] Kuo CH, Huang PJ, Cheng YM, et al. Modified Mitchell osteotomy for hallux valgus. Foot Ankle 1998;19:585–9.
[45] Wu KK. Mitchell's bunionectomy and Wu's bunionectomy: a comparison of 100 cases of each procedure. Orthop 1990;13:1001–7.
[46] Shereff MJ, Sobel MA, Kummer FJ. The stability of fixation of first metatarsal osteotomies. Foot Ankle 1991;11:208–11.
[47] Trnka HJ, Parks BG, Ivanic G, et al. Six first metatarsal shaft osteotomies mechanical and immobilization comparisons. Clin Orthop 2000;381:256–65.
[48] Fox IM, Cuttic M, DeMarco P. The offset v modification of the chevron bunionectomy: a retrospective study. J Foot Surg 1992;31:615–20.
[49] Goforth WP, Martin JE. Eighteen-month retrospective study of Austin bunionectomy using single screw fixation. J Foot Surg 1993;32:69–74.
[50] Hattrup SJ, Johnson KA. Chevron osteotomy: analysis of factors in pateints' dissatisfaction. Foot Ankle 1985;5:327–32.
[51] Johnson KA, Cofield RH, Morrey BF. Chevron osteotomy for hallux valgus. Clin Orthop 1979;142:44–7.
[52] Klosok JK, Pring DJ, Jessop JH, et al. Chevron or Wilson metatarsal osteotomy for hallux valgus. J Bone Joint Surg 1993;75B:825–9.
[53] Peterson DA, Zilberfarb JL, Greene MA, et al. Avascular necrosis of the first metatarsal head: incidence in distal osteotomy combined with lateral soft tissue release. Foot Ankle 1994;15:59–63.
[54] Markbreiter LA, Thompson FM. Proximal metatarsal osteotomy in hallux valgus correction: a comparison of crescentic and chevron procedures. Foot Ankle Int 1997;18:71–6.

[55] Fokter SK, Podobnik J, Vengust V. Late results of modified Mitchell procedure for the treatment of hallux valgus. Foot Ankle Int 1999;20:296–300.
[56] Myerson MS. Hallux valgus. In: Myerson MS, editor. Foot and ankle disorders. Philadelphia: WB Saunders Company; 2000. p. 213–88.
[57] Lian GJ, Markoff K, Cracchiolo A. Strength of fixation constructs for basilar osteotomies of the first metatarsal. Foot Ankle 1992;13:509–14.

Return to Play Following Ankle Sprain and Lateral Ligament Reconstruction

Scott B. Shawen, MD[a,b,*], Theodora Dworak, MD[c], Robert B. Anderson, MD[b]

KEYWORDS

• Return to play • Ankle sprain • Ankle stabilization surgery • Ankle instability • Syndesmosis injury

KEY POINTS

- Ankle sprains are the most common musculoskeletal injury in athletes.
- Treatment should consist of activity modification and pain control with transition to early range of motion and functional rehabilitation to allow for quicker return to function and decreased reinjury rates.
- Patients with functional or mechanical instability that do not improve with rehabilitation or preventative measures should be considered for operative reconstruction of the lateral ligaments to prevent chronic degeneration, dysfunction, or deformity.
- Concurrent findings, such as osteochondral injury, peroneal tendon injury, loose bodies, impingement, and tarsal coalition, should be considered in patients with continued ankle pain. Advanced imaging with MRI and arthroscopy are tools to further evaluate these concurrent injuries.
- Athletes should return to play only after range of motion and strength of the injured extremity has returned. Athletes with history of prior ankle sprain should be prophylactically treated with either taping or bracing during participation in sport to prevent further and repetitive injury.

INTRODUCTION

Ankle sprains and lateral ankle instability are exceedingly common injuries. However, the incidence of injury varies depending on the activity level of the studied population. These injuries occur most often during axial loading of the foot with inversion stress and a plantar-flexed foot.[1] Subsequent repeat ankle sprain or improper rehabilitation

The views expressed in this article are those of the author and do not reflect the official policy of the Department of Army/Navy/Air Force, Department of Defense, or US Government.

[a] Uniformed Services University of the Health Sciences, Bethesda, MD, USA; [b] OrthoCarolina Foot & Ankle Institute, 2001 Vail Avenue, Suite 200B, Charlotte, NC 28207, USA; [c] Department of Orthopaedic Surgery, Walter Reed National Military Medical Center, 8901 Rockville Pike, Bethesda, MD 20889, USA
* Corresponding author.
E-mail address: scott.b.shawen@gmail.com

Clin Sports Med 35 (2016) 697–709
http://dx.doi.org/10.1016/j.csm.2016.05.012 sportsmed.theclinics.com
0278-5919/16/$ – see front matter Published by Elsevier Inc.

following initial injury can result in lateral ankle instability in up to 20% of patients.[2–4] Instability is either functional or mechanical in nature. Functional lateral ankle instability is often subjective without physical laxity of the joint and is a result of deficits in proprioception, postural control, or muscle strength.[3] Mechanical lateral ankle instability results as a structural deficiency in the surrounding ligaments of the ankle leading to increased laxity and unnecessary motion about the joint.[3] Both mechanical and functional ankle instability, if improperly managed, can put athletes at risk of further injury. Injury to the syndesmosis, sometimes referred to as high ankle sprain, is an additional form of ankle instability that is often more severe in extent and outcome.[5] Disruption of the anatomic structures of the syndesmosis can also lead to mechanical ankle instability, pain, and delayed recovery.

With the frequency of ankle sprains, lateral ligament instability, and syndesmotic injuries, it is essential to understand the underlying cause and risk factors for these conditions. Greater understanding allows for proper prevention, diagnoses, and treatment of athletes with these conditions. Appropriate initial treatment is critical to returning athletes to sport and preventing long-term morbidity. This article investigates the epidemiology, anatomy, diagnosis, and management of patients with ankles sprains and lateral ankle injuries.

EPIDEMIOLOGY AND RISK FACTORS

The incidence rate of ankle sprains is 2.15 per 1000 person-years in the general population of the United States.[6] However, incidence rates increase with exposure to sport occurring at a rate of 3.4 injuries per 1000 athlete exposures in the National Basketball Association and 2.06 per 1000 athlete-hours in soccer players.[7,8] Similarly, lateral ankle sprain and syndesmotic sprain are the most common foot and ankle injuries in collegiate football players occurring in 31% and 15% of players, respectively.[9] Although ankle injury is more common in collision sports, ankle sprains are frequently reported as the most common injury regardless of the type of athletic exposure.[7–12]

The incidence of ankle sprains also varies with demographics. Ankle sprains are more common in younger age groups, 15 to 19 years of age, and specifically males.[6] Some studies have shown an increased incidence in female athletes, whereas others demonstrate increased incidence in males.[6,13] The true difference in gender may be sport specific. Several studies have shown increased frequency of ankle sprains in female basketball players compared with their male counterparts or when compared with their female colleagues who participate in other sports, such as lacrosse, field hockey, volleyball, and soccer.[14–16]

Multiple studies have attempted to identify specific anatomic and physical risk factors for ankles sprains and chronic ankle instability. There is evidence to suggest increased frequency of ankle sprains in athletes with increasing body mass index and lower physical activity.[17,18] Some authors suggest athletes with muscle imbalances have an increased risk for ankle instability, whereas others have found significant risk with how the calcaneus moves during gait.[17,18] Poor postural stability has also been identified as a possible risk factor.[19]

Previous authors support the theory that some of these risks can be modified, whereas others are fundamental to the athlete and cannot be changed. Modifiable risk factors for ankle sprains include body mass index; use of preventative therapies, such as braces or tape; strengthening; participation in sport; player positions; and even playing surfaces and equipment.[9,13,20,21] Nonmodifiable risk factors include demographic factors, such as age, gender, and race, and anatomic factors, such as limb alignment, anatomic variation, and joint laxity.[13,18,19] However, the true relevance of these risk factors, modifiable or not, are difficult to discern because large systematic reviews evaluating such factors have poor consensus.[22,23]

Identifying risk factors and demographic contributions for syndesmosis injury in athletes has been more difficult with limited studies showing significance for specific risk factors. However, vertical jump distance and balance may play a role.[12] Additionally, in football, player position has been shown to have different rates of ankle injury.[9]

PATHOANATOMY

Unlike other joints in the body the tibiotalar joint is inherently stable given the complementing structures of the medial malleolus of the tibia and the medial shoulder of the talus. This structural stability continues on the lateral side with lateral malleolus of the fibula; however, the fibula is able to change positions to accommodate motion of the talus during ankle movement.[24] The boney constraints of the medial and lateral aspects of the ankle joint provide significant stability in the coronal plane attributing to the predominant motion of the tibiotalar joint being plantar and dorsiflexion in the sagittal plane.

The relationship of the fibula to the tibia is maintained by the ligamentous structures of the syndesmosis. These ligamentous structures include the anterior inferior tibiofibular ligament, posterior inferior tibiofibular ligament, inferior transverse ligament, interosseous ligament, and interosseous membrane. These structures allow for an increase in the intermalleolar distance during the swing phase of gait to accommodate for the dorsiflexion and clearance of the foot, and the distance decreases during the stance phase to provide stability to the ankle joint.[24] Recurrent injury to the syndesmosis in professional athletes has been reported to result in tibiofibular synostosis and/or heterotopic ossification leading to pain with impact activities and restricted range of motion.[12,24]

The surrounding ligamentous support of the ankle joint is also crucial to adding stability to the joint. The anterior talofibular ligament (ATFL) prevents anterior translation of the talus relative to the tibia and is often the first structure injured during an ankle sprain.[25] The calcaneofibular ligament (CFL) resists inversion of talus relative to the tibia but also provides stability to the subtalar joint; it is the second structure injured during an ankle sprain.[25] The posterior talofibular ligament prevents posterior translation of the talus relative to the tibia when the ankle is in neutral plantar flexion, but is rarely injured during inversion injury to the ankle.[26]

The superior aspect of the anterior lateral joint capsule is often overlooked as a structure that provides stability to the ankle. However, cadaveric studies have demonstrated that disruption of the anterior lateral joint capsule results in 18% of joint displacement in grade I ankle sprains and up to 33% of displacement in grade III injuries.[25] Similarly, the stabilization provided by the capsule is even more critical in chronic lateral ligament laxity.[27]

The musculature surrounding the ankle joint provides active stability to the ankle joint during motion. Specifically peroneus longus and brevis assist with counteracting inversion forces during injury. Injury to the peroneal tendons in patients with chronic ankle instability is thought to be the result of repetitive compression of the tendons along the posterior aspect of the fibula.[28] In addition, there is a risk of tendon subluxation given the orientation of fibers of the CFL and superior peroneal retinaculum.

The histology of acutely injured lateral ankle ligaments is not unlike other areas of anatomy. Broström and Sundelin[27] reported a predominance of hemorrhage and fibrous exudate exists immediately following injury, which is replaced by granulocytic infiltration, mononuclear cells, and fibroblast a few days following injury. Chronically lax ligaments, even though previously injured, are able to remodel into parallel collagen bundles not unlike normal ligamentous structure.[27] This is in contrast to the degeneration that occurs in chronically injured tendons, such as the Achilles.

PATIENT EVALUATION

Critical to the treatment of ankle sprains and lateral ankle instability is patient evaluation through history and physical examination. Patients often present with difficulty weight bearing, lateral ankle pain, swelling, and ecchymosis.[29] Clinicians should differentiate a first-time ankle sprain from recurrent injury and discuss the mechanism of injury. Patients often report the sensation of their ankle giving way or describe multiple episodes of instability.[3] Symptoms of instability should also be discussed to determine functional from mechanical instability because treatment varies.[3] Patient level of function and athletic participation may also affect treatment and rehabilitation.

The physical examination is fundamental in the evaluation of patients with ankle sprains and lateral ankle instability. As with any patient with foot or ankle symptoms, evaluation of the hind foot alignment for planovalgus or cavovarus deformity should not be overlooked. Patients with a cavus deformity are more likely to develop attenuated lateral ligaments and subsequent lateral ankle instability.[30] These patients should be addressed with caution because the underlying cause of the ankle problem is likely from their malalignment and traditional soft tissue reconstruction options are likely to fail. The ability to weight bear following injury and the specific anatomic location of pain on examination can assist with determining the need for imaging using the Ottawa ankle rules.[29] Range of motion and gait are used to discern the acuity and severity of the injury at the time of evaluation.

Provocative tests for determining functional from mechanical instability include talar tilt, anterior drawer, squeeze, and external rotation stress tests. These tests may be less useful in the acute setting because of guarding on the patient's part. Talar tilt evaluates the integrity of the CFL and is performed with inversion stress to the lateral ankle.[1] Anterior drawer evaluates ATFL and is performed by directing and anterior force to the talus while stabilizing the tibia.[31] It is likely to be positive in patients with chronic injury as evident by the suction sign.[1,2] Anterior lateral drawer test is performed similarly to the traditional test only it allows for rotation of the talus about the intact medial ankle ligaments. It may identify the more subtle injury to the ATFL because detection of incompetence of that structure is not limited by the deltoid.[31] Squeeze test is used if there is suspicion for a syndesmotic injury; patients report ankle pain with squeezing of the fibula against the tibia at the mid-calf level.[5] External rotation stress test also evaluates the syndesmosis; the proximal tibia is stabilized and an external rotational force is applied to the foot and is considered positive if patients complain of pain.[1,5]

IMAGING

Should history and physical examination prompt further evaluation with imaging, clinicians should start with weight bearing standard three-view radiographs of the ankle and foot.[29] Additional anteroposterior and lateral radiographs of the leg are also critical to rule out syndesmotic injury or a high fibula fracture.[5] Although most patients with ankle sprains are likely to have normal radiographs, they should be used to rule out fracture or dislocation in the acute setting, and a tarsal coalition often associated with recurrent ankle sprains.[29,32] Stress radiographs or fluoroscopic imaging evaluating talar tilt and anterior talar translation can help evaluate the integrity of the lateral ankle ligaments. According to Lee and colleagues,[33] disruption of the posterior talofibular ligament is likely to be the only significant variable contributing to anterior talar translation; talar tilt on stress radiographs is affected by not only the integrity to the ATFL but also age and gender of the patient. Given the variability of stress views to the degree of ligamentous injury many authors question their clinical utility. However, knowledge of the extent of the lateral ankle instability on preoperative radiographs (particularly when asymmetric) provides assistance with anatomic reconstruction via intraoperative radiographic evaluation and can assist with radiographic evaluation postoperatively.[34]

Because radiographs are often of minimal benefit in patients with lateral ankle instability, MRI is frequently prescribed. MRI should be reserved for patients with chronic lateral ankle instability who fail a course of initial conservative treatment or who have unexplained pain in association with the ligament disorder. Although MRI of the ankle has excellent intraobserver reliability and positive predictive value for injury to the ATLF, its sensitivity is low for imaging, between 76% and 84%.[35] These limitations continue when evaluating for concomitant injuries of the ankle. Although MRI may identify associated pathology, such as osteochondral lesions, peroneal tendon tears, and loose bodies, the sensitivity of identifying such is still lower than with arthroscopy.[36,37] Clinicians should be systematic in evaluating the ankle joint during arthroscopy so as not to overlook these subtle concomitant injuries.

Ultrasound has recently become more widely used in the evaluation of musculoskeletal injuries. This modality can demonstrate increased elongation of the ATFL with an anterior drawer applied.[38] Similarly, syndesmotic injuries can also be evaluated with ultrasound techniques. Injury of the interosseous membrane is suspected if there is disruption of the normal linear hyperechoic structure between the tibia and fibula.[5] Unfortunately, ultrasound remains operator dependent with difficulty in reproducibility and interpretation.

PREVENTATIVE TREATMENT

Preventative treatment of ankle sprains and subsequent lateral ankle instability begins with identifying modifiable risk factors. Deficiencies in balance are addressed with single limb balance training and neuromuscluar control.[39,40] This training seems to be most useful at decreasing rates of ankle injury in patients that are at increased risk of injury, such as those with increased body mass index or those with history of previous injury.[39,40] Addressing deficiencies in ankle range of motion and muscle strength of the lower extremity has lower levels of evidence for injury prevention, but can easily be added to an athlete's training.[39]

Some authors have advocated the use of bracing to prevent ankle sprains. These braces provide additional lateral and medial mechanical support.[15] Although bracing had been shown to be useful in selective sports it is probably most useful in patients with recurrent ankle sprains rather than prophylaxis.[10,39]

Similar to bracing is the practice of taping. Taping is thought to assist the athlete by making up for the deficit in proprioception following the initial ankle injury. Although experimental models have difficulty validating this theory,[41] taping has proved to be effective in decreasing ankle injury in patients with previous injury and should be considered as preventative treatment.[10,39]

NONPHARMACOLOGIC TREATMENT

First time ankle sprains should be treated similarly to other musculoskeletal injuries using the PRICE acronym: protection, rest, ice, compression, and elevation.[39] Following improvement of initial symptoms, patients should progress to weight bearing as tolerated. Early range of motion has been shown to have improved functional outcomes and has equal pain scores compared with those treated with prolonged periods of immobilization.[42,43] An elastic compression wrap with an air stirrup type of brace can allow for a return to baseline walking speed faster than treatment with a brace or wrap alone.[44] Patients with low-grade syndesmotic injuries should be immobilized and institute protected weight bearing for a longer period of time, perhaps 3 to 4 weeks, as compared with athletes with a simple low-grade inversion ankle sprain.[45]

Physical therapy and rehabilitation are critical in preventing functional instability and decreasing a patient's risk for recurrent injury. Supervised physical therapy has better outcomes with regard to strength and proprioception for ankle sprains in the short term; however, improvement in reinjury rates and long-term functional results are similar to home therapy plans.[46] Consideration should be given to an evaluation with MRI for those patients with protracted functional instability or pain.

PHARMACOLOGIC TREATMENT OPTIONS

In addition to nonpharmacologic treatment, pharmacologic treatment assists with pain control, inflammation, and swelling. These medications should be used in conjunction with nonpharmacologic treatments. Nonsteroidal anti-inflammatory drugs in the form of cyclooxygenase inhibitors or specific cyclooxygenase-2 inhibitors, such as celecoxib are more effective than placebo at treating pain in patients with lateral ankle sprain.[47] Topical nonsteroidal anti-inflammatory drugs, such as diclofenac diethylamine 2.32% gel, have also been shown to be safe and effective for ankle sprains.[48] Acetaminophen extended release is as useful as ibuprofen with minimal side effects.[49] New treatments with platelet-rich plasma injections have shown minimal improvement in randomized studies and are likely of limited use in lateral ankle sprains.[50]

SURGICAL TREATMENT

An acute ankle sprain is not a typical indication for surgical intervention because immediate reconstruction or repair of the lateral ligaments has not shown to provide any improvement in long-term functional outcomes.[51] On the contrary, those patients that develop chronic instability are unlikely to have improvement in their symptoms without surgical intervention.[4] The increased risk for developing posttraumatic arthritis in these patients is suggested but remains in question.[4] It is our belief that patients who have failed formal rehabilitation of prior ankle sprains and have evidence for mechanical instability benefit from lateral ligament reconstruction.

Surgical treatment of lateral ankle instability varies depending on the specific type of lateral ligament reconstruction. The goal is to provide a stable ankle no matter what procedure is performed. Broström[2] described his technique for direct repair of the lateral ankle ligaments (ATFL only) with suture in 1966. Gould augmented this technique in 1980 with advancement of the extensor retinaculum and the procedure has been further modified by repairing both the ATFL and CFL back to the fibula using bone tunnels or suture anchors.[52,53] The modified Broström-Gould procedure provides an anatomic reconstruction of the lateral ligaments and is the most widely used.

The Broström-Gould techniques may fail to provide adequate stability in those patients found to have poor soft tissue envelope because of chronic injury or underlying cavovarus. Therefore additional reconstruction techniques have been described and often use modifications of the local anatomy to provide stability (Fig. 1). For example, Evans[54] described in 1953 a transposition of the peroneus brevis tendon through a

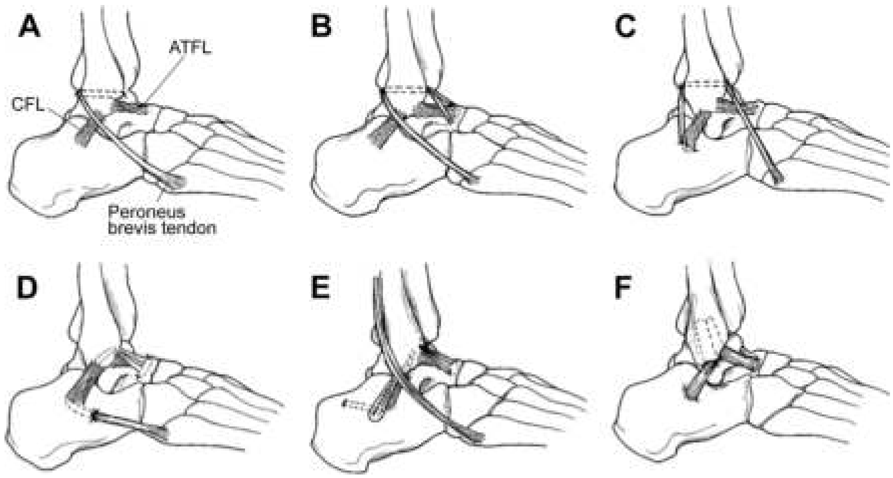


Fig. 1. Augmented reconstructions. (*A*) The Evans reconstruction uses a tenodesis of the peroneus brevis tendon to the fibula. (*B*) The Watson-Jones procedure reconstructs the ATFL in addition to tenodesis of the peroneus brevis tendon. (*C*) The Chrisman-Snook procedure uses a split peroneus brevis tendon to reconstruct the ATFL and CFL. (*D*) The procedure developed by Colville also uses a split peroneus brevis tendon to reconstruct the ATFL and CFL in an anatomic fashion without limiting subtalar motion. (*E*) The Anderson procedure uses the plantaris tendon to anatomically reconstruct both lateral ligaments without limiting subtalar motion. (*F*) The Sjølin technique uses periosteal flaps to augment an anatomic repair. (*From* Colville MR. Surgical treatment of the unstable ankle. J Am Acad Orthop Surg 1998;6:374; with permission.)

bone tunnel in the distal fibula followed by reattachment of the tendon to its remaining distal portion. Today this procedure is more commonly done, as described by Girard and colleagues,[55] using an anterior slip of the peroneus brevis as a checkrein, therefore avoiding complete disruption of the tendon and preserving most tendon function (**Fig. 2**). Similarly, the original Chrisman-Snook procedure or its modifications use an anterior slip of the peroneus brevis or allograft tendon grafts. In addition to rerouting

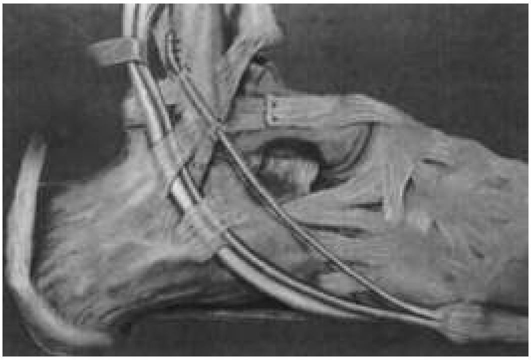


Fig. 2. The end-to-end repair of the calcaneofibular and anterior talofibular ligaments is achieved with nonabsorbable suture. The split tendon is rerouted through a drill hole in the distal fibula and is secured at both ends. (*From* Girard P, Anderson RB, Davis WH, et al. Clinical evaluation of the modified Broström-Evans procedure to restore ankle stability. Foot Ankle Int 1999;20(4):246–52.)

the tendon through the distal fibula, it is routed through a second bone tunnel in the calcaneus to recreate the CFL. In the original description the tendon is further sutured back to itself near the anterolateral ankle.[56]

There are several other procedures described to address lateral ankle instability. Given the dynamic stability the peroneal tendons provide, there is a theoretical reason to avoid violating them during reconstruction. As such, authors have described using extensor tendon from the fourth toe or semitendinosus allograft.[57,58] As an option to soft tissue augmentation the repair can also use suture tape with reported good results.[59] Patients who have lateral ankle instability in the setting of moderate-severe varus malalignment may benefit from supramalleolar or lateralizing calcaneal osteotomies, in addition to a more robust and augmented soft tissue reconstruction.[60]

Unstable syndesmotic injuries have traditionally been treated with rigid internal stabilization to achieve and maintain anatomic alignment, thus allowing for proper healing while preventing further injury. There has been controversy surrounding the type, size, and extent of screw fixation. Cadaveric studies have failed to show any significant difference between 3.5-mm and 4.5-mm screws or quadricortical versus tricortical fixation.[61] Furthermore, the syndesmosis is a true and functional joint, with inherent motion occurring between the fibula and tibia. As a result, implant removal has been advocated before returning the athlete to full activity to avoid the potential complications of screw breakage.[45] However, more recent clinical data refute this assumption, showing no correlation between screw breakage and pain.[62] To avoid this situation and to provide more physiologic, flexible fixation, there is a recent trend to treat these injuries with a modified suture button construct. Studies have shown little difference between modified suture construct for syndesmotic fixation versus screw fixation in a cadaveric model.[63] However, location of the fixation does seem to be important because there is increased displacement if fixation is placed too close to the tibial plafond.[64]

SURGICAL OUTCOMES, REHABILITATION, AND RETURN TO PLAY

Surgical outcomes for lateral ligament reconstruction are favorable. Maffulli and colleagues[65] published long-term results on athletes following a Broström procedure and found 58% were able to return to their preinjury level of sport, 16% were still competing but at a lower level, and 26% had discontinued sport participation but were still physically active. Similarly, long-term results of arthroscopic-assisted Broström-Gould are also positive. In Nery and colleagues's[66] cohort of 38 patients, only two patients had low functional scores. There was no difference in functional score between patients that had microfracture for osteochondral lesions at the time of surgery and those who had lateral ligament reconstruction alone after a follow-up of 9.8 years.

Return to play following syndesmosis ankle injury is often longer and of greater variability compared with lateral ankle sprains.[5] However, the outcome for patients undergoing treatment with greater than 1 year of syndesmotic instability are promising. Ryan and Rodriguez[67] showed that at 2 years follow-up 11 of 14 patients were able to return to their preinjury level of competition after treatment with arthroscopic debridement of the syndesmosis and fixation. As expected, the more severe the syndesmotic injury, the longer a player is unable to play. Miller and colleagues[5] found a positive correlation between the height of the syndesmotic injury and the number of days to return to play with the average time out of football being 15.5 days.

COMPLICATIONS

Although serious complications for lateral ligament reconstructions are rare, no surgery is without risk. Complications include infection, osteoarthritis, neuroma, disathesias, and recurrence of instabilty.[2] Complications for operatively treated syndesmosis injuries are similar to lateral ligament reconstruction. However, unique to syndesmotic operative treatment is obtaining an accurate reduction of the joint, which is difficult to evaluate intraoperatively, especially with fluoroscopy.[68] As a result, malreduction of the syndesmosis has been reported in up to 52% of cases. Even evaluation of the reduction on computed tomography can be inconsistent depending on the method of measurements used.[68,69] In the end, the morbidity of having a malreduced syndesmosis is questioned because implants are routinely removed or break allowing the fibula to return to its original anatomic location.

SUMMARY

Ankle sprains are an exceedingly common injury in an athletic population. Modifiable risk factors for injury need to be identified and addressed before engaging in athletic activity. Acute ankle injury treatment includes activity modification and pain control with focus on returning to weight bearing and range of motion when symptoms allow. Physical therapy focusing on strengthening and proprioception is the mainstay of recovery. When patients return to baseline, it is recommended that they return to the athletic field with external support in the form of a brace or tape apparatus to prevent further injury. Athletes with dysfunction that fail to respond to physical therapy or have recurrent injuries are indicated for lateral ligament reconstruction.

REFERENCES

1. Coughlin MJ, Saltzman CL, Anderson RB. Mann's surgery of the foot and ankle, 2-volume set: expert consult: online and print, 9e (Coughlin, surgery of the foot and ankle 2v set). Philadelphia: Saunders Elsevier Inc; 2013. p. 2336.
2. Broström L. Sprained ankles. VI. Surgical treatment of "chronic" ligament ruptures. Acta Chir Scand 1966;132(5):551–65.
3. Chen H, Li HY, Zhang J, et al. Difference in postural control between patients with functional and mechanical ankle instability. Foot Ankle Int 2014;35(10):1068–74.
4. Löfvenberg R, Kärrholm J, Lund B. The outcome of nonoperated patients with chronic lateral instability of the ankle: a 20-year follow-up study. Foot Ankle Int 1994;15(4):165–9.
5. Miller BS, Downie BK, Johnson PD, et al. Time to return to play after high ankle sprains in collegiate football players: a prediction model. Sports Health 2012;4(6):504–9.
6. Waterman BR, Owens BD, Davey S, et al. The epidemiology of ankle sprains in the United States. J Bone Joint Surg Am 2010;92(13):2279–84.
7. Drakos MC, Domb B, Starkey C, et al. Injury in the National Basketball Association: a 17-year overview. Sports Health 2010;2(4):284–90.
8. Kofotolis ND, Kellis E, Vlachopoulos SP. Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. Am J Sports Med 2007;35(3):458–66.
9. Kaplan LD, Jost PW, Honkamp N, et al. Incidence and variance of foot and ankle injuries in elite college football players. Am J Orthop (Belle Mead NJ) 2011;40(1):40–4.
10. Dizon JM, Reyes JJ. A systematic review on the effectiveness of external ankle supports in the prevention of inversion ankle sprains among elite and recreational players. J Sci Med Sport 2010;13(3):309–17.
11. Sankey RA, Brooks JH, Kemp SP, et al. The epidemiology of ankle injuries in professional rugby union players. Am J Sports Med 2008;36(12):2415–24.

12. Sman AD, Hiller CE, Rae K, et al. Predictive factors for ankle syndesmosis injury in football players: a prospective study. J Sci Med Sport 2014;17(6):586–90.
13. McCriskin BJ, Cameron KL, Orr JD, et al. Management and prevention of acute and chronic lateral ankle instability in athletic patient populations. World J Orthop 2015;6(2):161–71.
14. Beynnon BD, Vacek PM, Murphy D, et al. First-time inversion ankle ligament trauma: the effects of sex, level of competition, and sport on the incidence of injury. Am J Sports Med 2005;33(10):1485–91.
15. Frey C, Feder KS, Sleight J. Prophylactic ankle brace use in high school volleyball players: a prospective study. Foot Ankle Int 2010;31(4):296–300.
16. Hosea TM, Carey CC, Harrer MF. The gender issue: epidemiology of ankle injuries in athletes who participate in basketball. Clin Orthop Relat Res 2000;372:45–9.
17. Fousekis K, Tsepis E, Vagenas G. Intrinsic risk factors of noncontact ankle sprains in soccer: a prospective study on 100 professional players. Am J Sports Med 2012;40(8):1842–50.
18. Willems TM, Witvrouw E, Delbaere K, et al. Intrinsic risk factors for inversion ankle sprains in male subjects: a prospective study. Am J Sports Med 2005;33(3):415–23.
19. Willems TM, Witvrouw E, Delbaere K, et al. Intrinsic risk factors for inversion ankle sprains in females: a prospective study. Scand J Med Sci Sports 2005;15(5):336–45.
20. Hershman EB, Anderson R, Bergfeld JA, et al. An analysis of specific lower extremity injury rates on grass and FieldTurf playing surfaces in National Football League Games: 2000-2009 seasons. Am J Sports Med 2012;40(10):2200–5.
21. Janda DH, Bir C, Kedroske B. A comparison of standard vs. breakaway bases: an analysis of a preventative intervention for softball and baseball foot and ankle injuries. Foot Ankle Int 2001;22(10):810–6.
22. Hiller CE, Nightingale EJ, Lin CW, et al. Characteristics of people with recurrent ankle sprains: a systematic review with meta-analysis. Br J Sports Med 2011;45(8):660–72.
23. Witchalls J, Blanch P, Waddington G, et al. Intrinsic functional deficits associated with increased risk of ankle injuries: a systematic review with meta-analysis. Br J Sports Med 2012;46(7):515–23.
24. Whiteside LA, Reynolds FC, Ellsasser JC. Tibiofibular synostosis and recurrent ankle sprains in high performance athletes. Am J Sports Med 1978;6(4):204–8.
25. Boardman DL, Liu SH. Contribution of the anterolateral joint capsule to the mechanical stability of the ankle. Clin Orthop Relat Res 1997;341:224–32.
26. Clanton TO, Campbell KJ, Wilson KJ, et al. Qualitative and quantitative anatomic investigation of the lateral ankle ligaments for surgical reconstruction procedures. J Bone Joint Surg Am 2014;96(12):e98.
27. Broström L, Sundelin P. Sprained ankles. IV. Histologic changes in recent and "chronic" ligament ruptures. Acta Chir Scand 1966;132(3):248–53.
28. Bonnin M, Tavernier T, Bouysset M. Split lesions of the peroneus brevis tendon in chronic ankle laxity. Am J Sports Med 1997;25(5):699–703.
29. Bachmann LM, Kolb E, Koller MT, et al. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. BMJ 2003;326(7386):417.
30. Larsen E, Angermann P. Association of ankle instability and foot deformity. Acta Orthop Scand 1990;61(2):136–9.

31. Miller AG, Myers SH, Parks BG, et al. Anterolateral drawer versus anterior drawer test for ankle instability: a biomechanical model. Foot Ankle Int 2016;37(4): 407–10.
32. Omey ML, Micheli LJ. Foot and ankle problems in the young athlete. Med Sci Sports Exerc 1999;31(7 Suppl):S470–86.
33. Lee KM, Chung CY, Kwon SS, et al. Relationship between stress ankle radiographs and injured ligaments on MRI. Skeletal Radiol 2013;42(11):1537–42.
34. Haytmanek CT, Williams BT, James EW, et al. Radiographic identification of the primary lateral ankle structures. Am J Sports Med 2015;43(1):79–87.
35. Kim YS, Kim YB, Kim TG, et al. Reliability and validity of magnetic resonance imaging for the evaluation of the anterior talofibular ligament in patients undergoing ankle arthroscopy. Arthroscopy 2015;31(8):1540–7.
36. O'Neill PJ, Van Aman SE, Guyton GP. Is MRI adequate to detect lesions in patients with ankle instability. Clin Orthop Relat Res 2010;468(4):1115–9.
37. Roemer FW, Jomaah N, Niu J, et al. Ligamentous injuries and the risk of associated tissue damage in acute ankle sprains in athletes: a cross-sectional MRI Study. Am J Sports Med 2014;42(7):1549–57.
38. Croy T, Saliba SA, Saliba E, et al. Differences in lateral ankle laxity measured via stress ultrasonography in individuals with chronic ankle instability, ankle sprain copers, and healthy individuals. J Orthop Sports Phys Ther 2012;42(7):593–600.
39. Kaminski TW, Hertel J, Amendola N, et al. National Athletic Trainers' Association position statement: conservative management and prevention of ankle sprains in athletes. J Athl Train 2013;48(4):528–45.
40. McHugh MP, Tyler TF, Mirabella MR, et al. The effectiveness of a balance training intervention in reducing the incidence of noncontact ankle sprains in high school football players. Am J Sports Med 2007;35(8):1289–94.
41. Refshauge KM, Raymond J, Kilbreath SL, et al. The effect of ankle taping on detection of inversion-eversion movements in participants with recurrent ankle sprain. Am J Sports Med 2009;37(2):371–5.
42. Bleakley CM, O'Connor SR, Tully MA, et al. Effect of accelerated rehabilitation on function after ankle sprain: randomised controlled trial. BMJ 2010;340:c1964.
43. Prado MP, Mendes AA, Amodio DT, et al. A comparative, prospective, and randomized study of two conservative treatment protocols for first-episode lateral ankle ligament injuries. Foot Ankle Int 2014;35(3):201–6.
44. Beynnon BD, Renström PA, Haugh L, et al. A prospective, randomized clinical investigation of the treatment of first-time ankle sprains. Am J Sports Med 2006;34(9):1401–12.
45. Miller TL, Skalak T. Evaluation and treatment recommendations for acute injuries to the ankle syndesmosis without associated fracture. Sports Med 2014;44(2): 179–88.
46. Feger MA, Herb CC, Fraser JJ, et al. Supervised rehabilitation versus home exercise in the treatment of acute ankle sprains: a systematic review. Clin Sports Med 2015;34(2):329–46.
47. Ekman EF, Fiechtner JJ, Levy S, et al. Efficacy of celecoxib versus ibuprofen in the treatment of acute pain: a multicenter, double-blind, randomized controlled trial in acute ankle sprain. Am J Orthop (Belle Mead NJ) 2002;31(8):445–51.
48. Predel HG, Hamelsky S, Gold M, et al. Efficacy and safety of diclofenac diethylamine 2.32% gel in acute ankle sprain. Med Sci Sports Exerc 2012;44(9): 1629–36.

49. Dalton JD, Schweinle JE. Randomized controlled noninferiority trial to compare extended release acetaminophen and ibuprofen for the treatment of ankle sprains. Ann Emerg Med 2006;48(5):615–23.
50. Rowden A, Dominici P, D'Orazio J, et al. Double-blind, randomized, placebo-controlled study evaluating the use of platelet-rich plasma therapy (PRP) for acute ankle sprains in the emergency department. J Emerg Med 2015;49(4):546–51.
51. Kaikkonen A, Kannus P, Järvinen M. Surgery versus functional treatment in ankle ligament tears. A prospective study. Clin Orthop Relat Res 1996;326:194–202.
52. Gould N, Seligson D, Gassman J. Early and late repair of lateral ligament of the ankle. Foot Ankle 1980;1(2):84–9.
53. Hu CY, Lee KB, Song EK, et al. Comparison of bone tunnel and suture anchor techniques in the modified Broström procedure for chronic lateral ankle instability. Am J Sports Med 2013;41(8):1877–84.
54. Evans DL. Recurrent instability of the ankle; a method of surgical treatment. Proc R Soc Med 1953;46(5):343–4.
55. Girard P, Anderson RB, Davis WH, et al. Clinical evaluation of the modified Brostrom-Evans procedure to restore ankle stability. Foot Ankle Int 1999;20(4):246–52.
56. Chrisman OD, Snook GA. Reconstruction of lateral ligament tears of the ankle. An experimental study and clinical evaluation of seven patients treated by a new modification of the Elmslie procedure. J Bone Joint Surg Am 1969;51(5):904–12.
57. Ahn JH, Choy WS, Kim HY. Reconstruction of the lateral ankle ligament with a long extensor tendon graft of the fourth toe. Am J Sports Med 2011;39(3):637–44.
58. Clanton TO, Viens NA, Campbell KJ, et al. Anterior talofibular ligament ruptures, part 2: biomechanical comparison of anterior talofibular ligament reconstruction using semitendinosus allografts with the intact ligament. Am J Sports Med 2014;42(2):412–6.
59. Cho BK, Park KJ, Kim SW, et al. Minimal invasive suture-tape augmentation for chronic ankle instability. Foot Ankle Int 2015;36(11):1330–8.
60. Mann HA, Filippi J, Myerson MS. Intra-articular opening medial tibial wedge osteotomy (plafond-plasty) for the treatment of intra-articular varus ankle arthritis and instability. Foot Ankle Int 2012;33(4):255–61.
61. Markolf KL, Jackson SR, McAllister DR. Syndesmosis fixation using dual 3.5 mm and 4.5 mm screws with tricortical and quadricortical purchase: a biomechanical study. Foot Ankle Int 2013;34(5):734–9.
62. Hamid N, Loeffler BJ, Braddy W, et al. Outcome after fixation of ankle fractures with an injury to the syndesmosis: the effect of the syndesmosis screw. J Bone Joint Surg Br 2009;91(8):1069–73.
63. Ebramzadeh E, Knutsen AR, Sangiorgio SN, et al. Biomechanical comparison of syndesmotic injury fixation methods using a cadaveric model. Foot Ankle Int 2013;34(12):1710–7.
64. Miller RS, Weinhold PS, Dahners LE. Comparison of tricortical screw fixation versus a modified suture construct for fixation of ankle syndesmosis injury: a biomechanical study. J Orthop Trauma 1999;13(1):39–42.
65. Maffulli N, Del Buono A, Maffulli GD, et al. Isolated anterior talofibular ligament Broström repair for chronic lateral ankle instability: 9-year follow-up. Am J Sports Med 2013;41(4):858–64.
66. Nery C, Raduan F, Del Buono A, et al. Arthroscopic-assisted Broström-Gould for chronic ankle instability: a long-term follow-up. Am J Sports Med 2011;39(11):2381–8.

67. Ryan PM, Rodriguez RM. Outcomes and return to activity after operative repair of chronic latent syndesmotic instability. Foot Ankle Int 2016;37(2):192–7.
68. Koenig SJ, Tornetta P, Merlin G, et al. Can we tell if the syndesmosis is reduced using fluoroscopy. J Orthop Trauma 2015;29(9):e326–30.
69. Knops SP, Kohn MA, Hansen EN, et al. Rotational malreduction of the syndesmosis: reliability and accuracy of computed tomography measurement methods. Foot Ankle Int 2013;34(10):1403–10.

International Orthopaedics (SICOT) (2013) 37:1771–1780
DOI 10.1007/s00264-013-2012-4

ORIGINAL PAPER

Angular correction and complications of proximal first metatarsal osteotomies for hallux valgus deformity

Reinhard Schuh · Madeleine Willegger · Johannes Holinka · Robin Ristl · Reinhard Windhager · Axel H. Wanivenhaus

Received: 3 June 2013 / Accepted: 24 June 2013 / Published online: 25 July 2013

Abstract

Purpose Proximal first metatarsal osteotomies are recommended for the surgical treatment of moderate to severe hallux valgus deformity. This study aimed to compare correction of intermetatarsal and hallux valgus angles and complications of proximal crescentic, Ludloff, proximal opening wedge, proximal closing wedge, proximal chevron and other proximal first metatarsal osteotomies.

Methods A systematic search for the keywords "(bunion OR hallux) AND (proximal OR crescentic OR basilar OR opening OR closing OR shelf OR Ludloff) AND osteotomy" in the online databases MEDLINE, Embase, CINAHL, Cochrane Central Register of Controlled Trials and Cochrane Database of Systematic Reviews was performed.

Results There was a mean correction of hallux valgus angle of 20.1° [confidence interval (CI) 18.7–21.4] and of intermetatarsal angle of 8.1° (CI 7.7–8.9). The overall complication rate reached 18.7 %.

Conclusions The results of this study reveal higher corrective power of proximal osteotomies compared to meta-analysis data on diaphyseal osteotomies.

Introduction

Hallux valgus deformity is characterised by lateral deviation of the great toe and medial deviation of the first metatarsal, leading to subluxation of the respective joint [1, 2]. More than 200 different surgical methods have been described to address this pathological condition. Correctional metatarsal osteotomies are the surgical treatment of choice for symptomatic hallux valgus deformity [3]. They can be performed at the distal, diaphyseal or proximal aspect of the first metatarsal. Osteotomies of the first metatarsal typically create three-dimensional effects on the distal fragment, affecting alignment in the axial and sagittal planes as well as rotationally [4].

The severity of deformity is classified by radiological criteria [5]. Mild deformity has less than 15° intermetatarsal 1–2 angle (IMA), moderate deformity has 15–20° IMA and severe deformity has more than 20° IMA [6]. Mathematical analysis revealed that distal metatarsal osteotomies (DMO) provide less corrective power than proximal metatarsal osteotomies (PMO). Therefore, DMO are preferred to correct mild to moderate hallux valgus deformities. For severe hallux valgus deformity with an IMA in excess of 20°, a PMO is indicated.

Fixation in PMO is critical and complications due to high lever forces acting on the osteotomy site are common. The complications include shortening and dorsiflexion malunion leading to first ray insufficiency. Due to this fact, its use is limited in spite of its theoretically superior corrective power compared to DMO [3, 6, 7].

The most common proximal osteotomies are the crescentic osteotomy, the Ludloff osteotomy, the proximal chevron osteotomy, the proximal opening wedge osteotomy and the proximal closing wedge osteotomy. The proximal crescentic osteotomy achieves correction by angular rotation after performing a cut dorsal to plantar with a crescentic saw blade at the proximal aspect of the first metatarsal. The Ludloff osteotomy is an oblique osteotomy starting 1.5 cm distal to the metatarsocuneiform joint on the dorsal aspect of the metatarsal base. The proximal chevron osteotomy represents a V-shaped displacement osteotomy with 60° of angulation

R. Schuh (✉) · M. Willegger · J. Holinka · R. Windhager · A. H. Wanivenhaus
Department of Orthopaedics, Medical University of Vienna, Waehringer Guertel 18-20, 1090 Vienna, Austria
e-mail: reinhard.schuh@meduniwien.ac.at

R. Ristl
Section for Medical Statistics, Center for Medical Statistics, Informatics, and Intelligent Systems, Medical University of Vienna, Vienna, Austria

between the dorsal and the plantar cut. Proximal opening and closing wedge osteotomies both correct the IMA by rotation of the metatarsal bone. Whereas opening wedge osteotomy provides lengthening, closing wedge osteotomy shortens the first metatarsal bone (Fig. 1) [7, 8].

Many authors have studied the clinical and radiographic results of PMO. However, there exist only a few comparative studies with a limited number of patients. Therefore, the aim of this study was to compare (1) the efficacy of PMO in terms of corrective power and (2) the complication rate of PMO.

Methods

Search method

A systematic search for the keywords "(bunion OR hallux) AND (proximal OR crescentic OR basilar OR opening OR closing OR shelf OR ludloff) AND osteotomy" in the online databases MEDLINE, Embase, CINAHL, Cochrane Central Register of Controlled Trials and Cochrane Database of Systematic Reviews was performed. English and German language studies previous to August 2012 were included in the analysis. A manual reference check of all accepted papers and recent reviews was performed to supplement the electronic searches and to identify any additional potentially relevant studies. Literature search and selection were performed according to the Cochrane Handbook for Systematic Reviews (http://hiv.cochrane.org/sites/hiv.cochrane.org/files/uploads/Ch13_NRS.pdf).

The titles and abstracts were reviewed in duplicate and independently for eligibility. Two reviewers then independently extracted all relevant information about outcome-related demographic data. For a study to satisfy the criteria for inclusion, the authors had to have reported on (1) pre- and post-operative IMA and hallux valgus angle (HVA), (2) number of feet, (3) length of follow-up and (4) type of procedure and method of fixation.

We included systematic reviews of randomised controlled trials (RCTs) and prospective and retrospective case-control and case-series studies. There was no restriction to RCTs because our aim was to establish the angular correction obtained by the aforementioned osteotomies when used for the surgical correction of hallux valgus deformity. There was no criterion for minimum length of follow-up because radiographic angular correction can be established early after the operation [1]. The level of evidence for each study was assigned according to the guidelines of the American Academy of Orthopaedic Surgeons (AAOS) [9].

Outcome parameters

The two target outcomes analysed were the differences in HVA and in IMA before and after surgery (delta HVA and delta IMA). These outcome measures were to be compared between the six surgical methods "Ludloff" (method 1), "proximal crescentic osteotomy" (method 2), "proximal opening wedge osteotomy" (method 3), "proximal closing wedge osteotomy" (method 4), "proximal chevron osteotomy" (method 5) and "other methods" (method 6).

As a secondary outcome parameter, the rate of overall, major and minor complications was compared between the surgical methods and separately between fixation methods 1 to 7 (1=screw, 2=plate, 3=locking plate, 4=wire, 5=pin, 6=external fixation and 7=combination screw/wire). Major complications were defined as complications that might require revision surgery. These included nonunion, dorsiflexion malunion, recurrence, hallux varus, fracture, deep infection and implant failure. Minor complications included superficial infection or numbness.

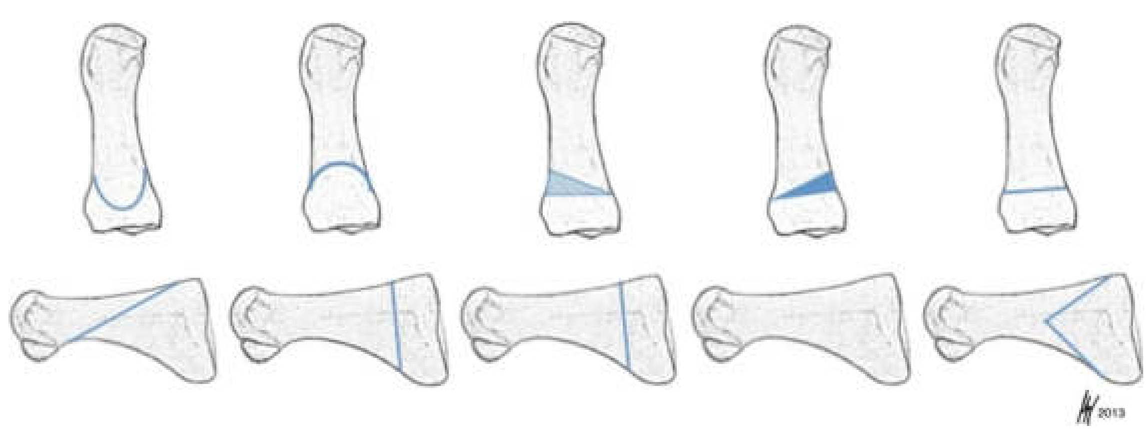


Fig. 1 Dorsoplantar and lateral views of different proximal first metatarsal osteotomies. *From left to right*: Ludloff osteotomy, proximal crescentic osteotomy, proximal opening wedge osteotomy, proximal closing wedge osteotomy and proximal chevron osteotomy

Data analysis

For those studies where the range (in terms of minimum and maximum observed values) was reported as measure of variance, the standard deviation was estimated by a maximum likelihood method making use of the reasonable assumption of normally distributed values and the available mean, minimum and maximum values. The correlation between pre- and post-treatment values was estimated from all studies where an estimate for the standard deviation was available for pre- and post-treatment and for the mean difference. This estimate was 0.43 for HVA and 0.23 for IMA.

Using the estimated correlations, the standard deviations for the pre- to post-treatment differences were calculated. For studies where no measure of variance was reported, the standard deviation of the pre- to post-treatment difference was estimated as the pooled standard deviation of all other studies.

A random effects model was fit for each surgical method separately to calculate the mean treatment effect in terms of delta IMA or delta HVA and to estimate the variability between studies. The reported value I^2 is an estimate of the relative amount of total variability accounted for by the heterogeneity between studies. Confidence intervals (CI) for the group mean effects were calculated. Funnel plots were drawn to check for publication bias. Inspection of the funnel plots showed no sign of publication bias.

Multiple random effects models were fit including surgery type as moderator. From these models the hypothesis of equal mean effects in each surgery group was tested. These calculations were performed using the library metafor (http://www.jstatsoft.org/v36/i03) in the statistical computing environment R2.14.2 [10].

The negative binomial distribution was used to model the complication rates in the different studies. Generalised linear models were fit to explain the complication rate per treated feet by type of surgery or type of fixation for overall, major and minor complications separately. In these models, the study values were weighted by the respective sample sizes. Likelihood ratio tests were calculated to test the hypothesis of no difference between the surgery or fixation types, respectively. Estimated mean values for the complication rate per feet and 95 % CI were calculated. These calculations were done using PROC GENMOD in SAS 9.3.

Results

The initial search yielded 808 citations. The final database included 62 primary studies eligible for meta-analysis [11–68]. Four of these were identified as kinship studies. The studies included a total amount of 2,843 feet. Detailed distribution is presented in Table 1. Study attrition is shown in Fig. 2.

Analysis of level of evidence of the selected studies revealed that the majority of studies were case series (level IV) (n=43). Ten studies were level III, three studies level II and two studies level I (Fig. 4).

There were 974 feet that underwent proximal crescentic osteotomy, 596 feet proximal closing wedge osteotomy, 326 feet proximal opening wedge osteotomy, 446 feet proximal chevron osteotomy, 402 feet Ludloff osteotomy and 99 feet where other types of proximal first metatarsal osteotomies were performed (Fig. 4).

For all proximal first metatarsal osteotomies the mean correction of HVA was 20.1° (CI 18.7–21.4) and of IMA 8.1° (CI 7.7–8.9). Subgroup analysis revealed an average angular correction of HVA of 22.4° (CI 19.3–25.7°, I^2=93 %) for Ludloff osteotomy, 23.3° (CI 21.4–25.2°, I^2=92 %) for proximal crescentic osteotomy, 16.2° (14.0–18.0°, I^2=87 %) for proximal opening wedge osteotomy, 19.6° (CI 16.4–22.9°, I^2=95 %) for proximal closing wedge osteotomy, 21.0° (18.4–24.2°, I^2=93 %) for proximal chevron osteotomy and 17.1° (CI 16.0–19.1°, I^2=50 %) for other osteotomies. The difference was statistically significant (p=0.0056).

Correction of IMA averaged 8.2° (CI 6.2–9-2°, I^2=95 %) for Ludloff osteotomy, 9.2° (CI 8.2–10.2°, I^2=89 %) for proximal crescentic osteotomy, 8.2° (CI 7.2–9.0°, I^2=85 %) for proximal opening wedge osteotomy, 7.2° (CI 6.2–9.2°, I^2=96 %) for proximal closing wedge osteotomy, 8.2° (CI 7.2–10.0°, I^2=91 %) for proximal chevron osteotomy and 7.2° (CI 3.2–8.2°, I^2=56 %) for other osteotomies. However, the intergroup difference was not statistically significant (p=0.144) (Fig. 3).

A total of 534 complications (18.7 %) occurred with 364 major (12.8 %), 92 minor (3.2 %) and 78 other complications (2.7 %). The most common major complications were hallux varus (n=121, 4.3 %), recurrence (n=99, 3.5 %) and dorsiflexion malunion (n=59, 2.5 %) respectively. Results of the GENMOD procedure to compare complications are presented in Tables 2 and 3. We found statistically significant differences for major complications between the different surgical methods (p=0.025). The mean major complication rates were 17.5 % (CI 12.8–23.9) in patients who underwent Ludloff osteotomy, 11.7 % (CI 7.2–18.0) for proximal crescentic osteotomy, 14.3 % (CI 8.1–25.1) for proximal opening wedge osteotomy, 15.7 % (CI 10.4–23.4) for proximal closing wedge, 6.1 % (CI 3.6–10.2) for proximal chevron osteotomy and 24.6 % (CI 10.1–57.8) for other methods. From these mean values and CI the main difference was observed for proximal chevron osteotomy with major complication rates smaller than for the other methods (Fig. 4).

Analysis of methods of fixation revealed statistically significant differences for total (p=0.027) and minor complications

Table 1 Detailed information about the studies included regarding first author, year of publication, level of evidence, number of feet, surgical methods, IMA correction (mean, 95 % CI), HVA correction (mean, 95 % CI) and total number of complications

First author (year)	Level of evidence	Number of feet (patients)	Type of surgery	Delta IMA (95 %CI)	Delta HVA (95 %CI)	Complications
Bar-David (1991) [11]	III	20 (18)	Basilar (Balacescu or Juvara)	9.30 (7.44–11.16)	15.60 (12.81–18.39)	1
Cedell (1982) [12]	IV	46 (43)	Proximal closing wedge	5.80 (4.58–7.02)	20.30 (17.76–22.84)	8
Chiang (2012) [13]	III	30 (30)	Modified Ludloff	4.60 (3.20–6.00)	21.00 (17.89–24.11)	12
Chiodo (2004) [14]	IV	82 (75)	Ludloff	9.00 (8.09–9.91)	20.00 (18.10–21.90)	15
Choi (2009) [15]	III	52 (52)	Ludloff	10.00 (9.04–10.96)	26.40 (22.40–28.76)	4
Choi (2009) [15]	III	46 (46)	Proximal chevron	10.70 (7.95–13.45)	27.20 (24.09–30.31)	3
Chow (2008) [16]	IV	32 (26)	Proximal crescentic	6.60 (5.15–8.06)	17.20 (14.16–20.24)	3
Cooper (2007) [17]	IV	23 (23)	Proximal opening wedge	7.00 (6.00–8.00)	15.00 (13.16–16.81)	4
Coughlin (2007) [19]	IV	122 (103)	Proximal crescentic	9.10 (8.35–9.85)	20.00 (18.44–21.56)	21
Coughlin (2005) [18]	IV	33 (27)	Proximal crescentic	8.40 (6.96–9.84)	23.00 (20.00–26.00)	
Day (2011) [20]	IV	70 (57)	Proximal closing wedge	8.80 (8.03–9.57)	20.00 (18.48–21.52)	7
Dreeben (1996) [21]	IV	28 (20)	Proximal crescentic	11.30 (9.53–13.07)	22.70 (18.94–26.46)	6
Easley (1996) [22]	I	41 (29)	Proximal crescentic	9.00 (7.71–10.29)	22.00 (19.31–24.69)	7
Easley (1996) [22]	I	43 (37)	Proximal chevron	9.50 (8.24–10.76)	20.10 (17.47–22.73)	9
Fadel (2008) [23]	IV	40 (32)	Proximal closing wedge	6.10 (4.83–7.37)	22.00 (18.84–25.16)	2
Fox (1999) [24]	IV	29 (27)	Proximal crescentic	13.50 (11.96–15.04)	22.60 (19.40–25.80)	5
Gallentine (2007) [25]	IV	20 (16)	Proximal chevron	7.60 (6.36–8.84)	16.00 (12.66–19.34)	2
Glover (2008) [26]	IV	24	Mau osteotomy	6.79 (5.56–8.02)	18.34 (15.37–21.31)	17
Granberry (1995) [27]	II	31 (22)	Proximal closing wedge	9.20 (7.71–10.69)	24.00 (21.24–26.76)	11
Haas (2007) [28]	III	20 (19)	Proximal closing wedge	7.85 (6.96–8.74)	19.90 (16.66–23.14)	
Hofstaetter (2006) [29]	IV	70 (67)	Ludloff	10.00 (9.01–10.99)	25.00 (22.94–27.06)	14
Hyer (2008) [30]	II	10 (10)	Proximal crescentic	5.80 (3.00–8.60)	16.50 (10.26–22.74)	23
Hyer (2008) [30]	II	24 (24)	Mau osteotomy	6.70 (5.47–7.93)	18.34 (15.37–21.31)	12
Jensen (1989) [31]	IV	41 (27)	Proximal closing wedge	11.00 (9.37–12.63)	26.00 (23.32–28.68)	7
Lee (2008) [33]	I	85 (65)	Proximal chevron	7.60 (6.68–8.52)	22.60 (20.70–24.50)	5
Lee (2007) [34]	IV	35 (29)	Proximal chevron	11.80 (10.56–13.04)	27.80 (25.05–30.55)	5
Lee (2009) [32]	III	69 (52)	Proximal chevron	10.20 (9.35–11.05)	24.05 (22.28–25.82)	3
Limbird (1989) [35]	III	22 (15)	Proximal opening wedge	7.00 (5.23–8.77)	14.40 (10.73–18.07)	
Lüthje (1990) [36]	IV	59 (44)	Proximal closing wedge	4.00 (2.92–5.08)	6.00 (3.76–8.24)	
Mann (1992) [37]	IV	109 (75)	Proximal crescentic	8.00 (7.19–8.81)	21.30 (19.44–23.16)	37
Markbreiter (1997) [38]	III	25 (18)	Proximal crescentic	10.20 (8.54–11.86)	26.20 (22.76–29.64)	4
Markbreiter (1997) [38]	III	25 (18)	Proximal chevron	9.70 (8.04–11.36)	19.70 (16.26–23.14)	3
Nedopil (2010) [39]	IV	86 (66)	Proximal closing wedge	11.10 (10.22–11.98)	22.10 (20.44–23.76)	6
Okuda (2005) [41]	III	55 (36)	Proximal crescentic	10.00 (9.02–10.98)	24.00 (21.86–26.14)	6
Okuda (2000) [40]	IV	47 (33)	Proximal crescentic	10.70 (9.46–11.94)	24.20 (21.89–26.51)	3
Okuda (2008) [42]	IV	54 (41)	Proximal crescentic	9.30 (8.46–10.14)	24.00 (22.35–25.65)	11
Paczesny (2009) [43]	IV	20 (16)	Proximal closing wedge	5.00 (3.29–6.71)	14.10 (11.25–16.95)	1
Pearson (1991) [44]	IV	31 (27)	Proximal curved	6.30 (4.17–8.43)	18.80 (15.11–22.49)	7
Pehlivan (2004) [45]	IV	26 (26)	Proximal oblique crescentic	9.90 (8.54–11.26)	22.10 (20.29–23.91)	1
Petratos (2008) [46]	IV	39 (32)	Proximal crescentic	7.30 (5.97–8.63)	14.00 (11.24–16.76)	2
Randhawa (2009) [47]	IV	31 (29)	Opening wedge	10.30 (7.67–12.93)	13.70 (11.31–16.09)	
Resch (1989) [48]	IV	27 (25)	Proximal closing wedge	3.00 (1.41–4.59)	13.00 (9.69–16.31)	8
Ritschl (1999) [49]	IV	80	Proximal crescentic	9.60 (8.77–10.43)	27.70 (25.63–29.77)	
Robinson (2009) [50]	II	57	Ludloff	6.00 (4.90–7.10)	16.00 (13.72–18.28)	3
Sammarco (1998) [52]	IV	72 (55)	Proximal chevron	6.00 (5.07–6.93)	15.00 (13.26–16.74)	11
Sammarco (1993) [51]	IV	51 (43)	Proximal chevron	7.30 (6.33–8.27)	19.30 (16.82–21.78)	9
Saragas (2009) [53]	IV	64 (46)	Opening wedge	6.40 (5.64–7.16)	14.70 (12.94–16.46)	9

Table 1 (continued)

First author (year)	Level of evidence	Number of feet (patients)	Type of surgery	Delta IMA (95 %CI)	Delta HVA (95 %CI)	Complications
Seiberg (1994) [54]	III	31 (25)	Proximal closing wedge	12.10 (10.98–13.22)	31.80 (28.50–35.10)	8
Señarís-Rodríguez (1998) [55]	III	10 (9)	Proximal closing wedge	5.62 (3.39–7.85)	17.25 (9.67–24.83)	3
Shurnas (2009) [56]	IV	84 (78)	Opening wedge	9.90 (9.09–10.71)	20.00 (18.52–21.48)	20
Smith (2009) [57]	IV	49 (47)	Proximal opening wedge	8.00 (7.09–8.91)	19.80 (18.55–21.05)	14
Takao (2007) [58]	IV	27 (22)	Proximal oblique-domed	8.40 (7.53–9.27)	28.50 (26.59–30.41)	
Tanaka (2008) [59]	IV	48 (37)	Proximal spherical (crescentic)	13.10 (12.05–14.15)	34.00 (31.62–36.38)	22
Thordarson (1992) [60]	IV	46 (32)	Proximal crescentic	10.20 (8.98–11.42)	23.70 (21.16–26.24)	6
Treadwell (2005) [61]	IV	5	Proximal closing wedge			4
Trnka (1999) [63]	IV	60 (42)	Proximal closing wedge	9.40 (8.20–10.60)	19.00 (16.14–21.86)	23
Trnka (2008) [62]	IV	111 (99)	Ludloff	9.00 (8.21–9.79)	26.00 (24.37–27.63)	32
Veri (2001) [64]	IV	37 (25)	Proximal crescentic	10.00 (8.75–11.25)	24.00 (20.50–27.50)	16
Walther (2008) [65]	IV	35 (35)	Opening base wedge	9.00 (8.13–9.87)		3
Wukich (2009) [66]	IV	18 (16)	Opening base wedge	9.00 (7.38–10.62)	13.50 (6.08–20.92)	6
Zembsch (1998) [67]	IV	50 (34)	Proximal closing wedge	10.00 (8.83–11.17)	19.00 (16.56–21.44)	25
Zettl (2000) [68]	IV	86 (70)	Proximal crescentic	10.00 (8.99–11.01)	26.50 (23.63–29.37)	25

($p<0.001$). For screw fixation there was a total complication rate of 24.3 % (CI 18.9–31.4) and a minor complication rate of 2.9 % (CI 1.9–4.5), and for plate fixation we found 16.2 % (CI 10.8–24.4) and 1.1 % (CI 0.4–3.5), respectively. For locking plate fixation the overall complication rate reached 9.1 % (CI 2.5–32.6) and minor complication rate reached 1.8 % (CI 0.2–

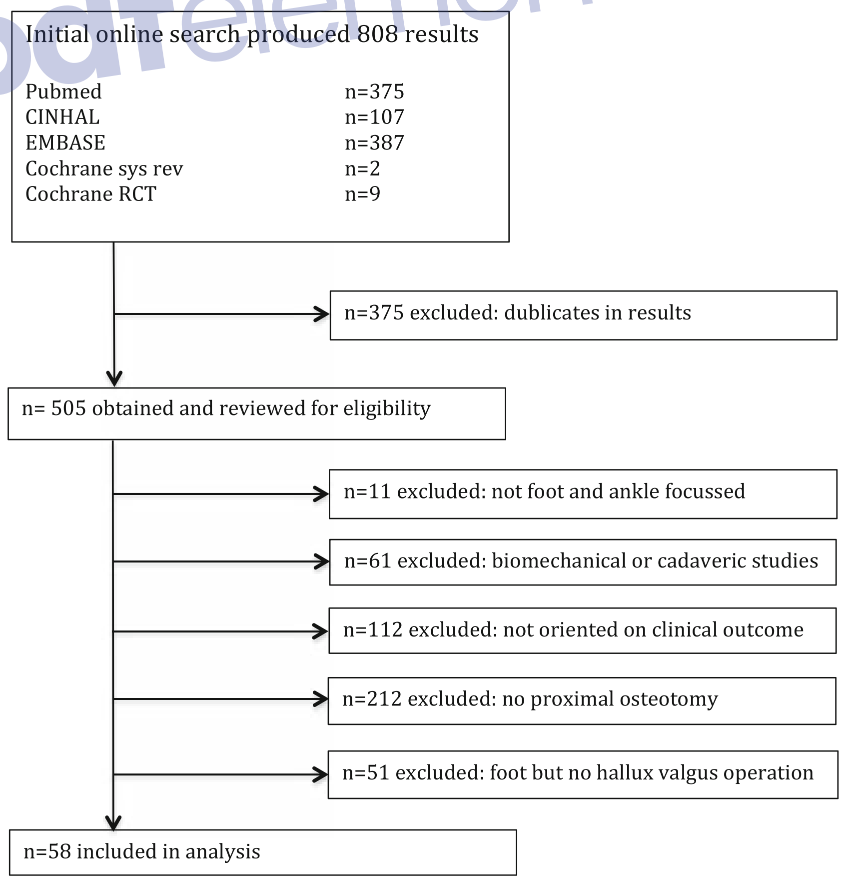


Fig. 2 Flow diagram outlining study search methods and selection

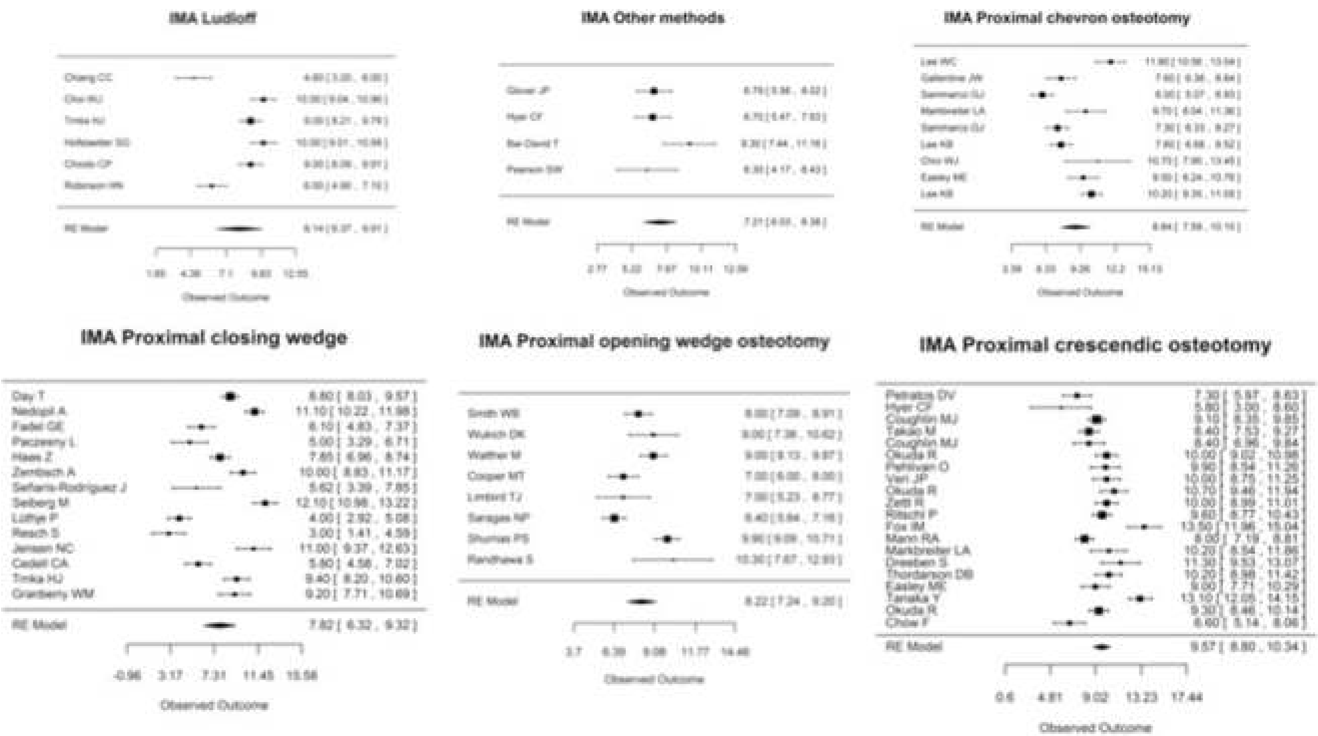


Fig. 3 Forest plots presenting the results of IMA correction for different surgical methods. *RE* random effects model

16.4), wire fixation showed 11.5 % (CI 7.7–17.0) and 2.9 % (CI 1.6–5.3), pin fixation showed 30.5 % (CI 18.5–50.1) and 14.4 % (CI: 8.0–25.7), external fixation showed 23.9 % (CI 7.4–77.6) and 8.7 % (CI 2.0–37.8) and combined screw/wire

Table 2 Complication rate for each surgical method, rate of major complications and rate of minor complications (95 % CI indicate the lower and upper limits of a 95 % CI for the mean)

Complication rates			
Type of surgery	Mean	SE	95 % CI
Total complications			
Proximal crescentic osteotomy	19.900	4.297	13.033–30.386
Ludloff osteotomy	23.741	3.481	17.811–31.646
Proximal opening wedge osteotomy	20.513	5.354	12.299–34.212
Proximal closing wedge osteotomy	21.857	4.112	15.117–31.602
Proximal chevron osteotomy	11.211	2.526	7.209–17.435
Others	37.374	15.210	16.833–82.981
Major complications			
Proximal crescentic osteotomy	11.692	2.858	7.241–18.878
Ludloff osteotomy	17.506	2.790	12.810–23.924
Proximal opening wedge osteotomy	14.286	4.098	8.142–25.067
Proximal closing wedge osteotomy	15.667	3.221	10.471–23.442
Proximal chevron osteotomy	6.054	1.621	3.582–10.233
Others	24.242	10.785	10.137–57.977
Minor complications			
Proximal crescentic osteotomy	2.985	1.458	1.146–7.776
Ludloff osteotomy	3.836	1.249	2.026–7.265
Proximal opening wedge osteotomy	2.197	1.381	0.640–7.536
Proximal closing wedge osteotomy	4.061	1.666	1.817–9.078
Proximal chevron osteotomy	4.035	1.784	1.696–9.601
Others	3.030	2.974	0.442–20.756

Table 3 Rate of total complications for each method of fixation, rate of major complications and rate of minor complications (95 % CI indicate the lower and upper limits of a 95 % CI for the mean)

Complication rates			
Type of fixation	Mean	SE	95 % CI
Total complications			
Screw	24.368	3.149	18.916–31.392
Plate	16.197	3.383	10.756–24.391
Locking plate	9.091	5.931	2.531–32.655
Wire	11.456	2.321	7.702–17.041
Pin	30.453	7.739	18.506–50.113
External fixation	23.913	14.362	7.369–77.600
Screw/wire	25.253	5.929	15.939–40.008
Major complications			
Screw	16.684	2.461	12.494–22.278
Plate	12.207	2.880	7.686–19.385
Locking plate	5.455	4.280	1.172–25.392
Wire	7.379	1.753	4.631–11.756
Pin	15.638	4.697	8.679–28.176
External fixation	8.696	6.666	1.935–39.069
Screw/wire	21.549	5.616	12.929–35.914
Minor complications			
Screw	2.932	0.649	1.899–4.526
Plate	1.174	0.567	0.455–3.028
Locking plate	1.818	2.042	0.201–16.435
Wire	2.913	0.895	1.593–5.323
Pin	14.403	4.268	8.057–25.746
External fixation	8.696	6.524	1.998–37.841
Screw/wire	1.010	0.624	0.300–3.391

fixation showed 25.3 % (CI 15.9–40.0) and 1.0 % (CI 0.3–3.4), respectively. Regarding minor complications it appears that pin fixation is associated with an increased rate while all other methods exhibit a similar level.

Discussion

The aim of this study was to assess corrective power and complications of proximal first metatarsal osteotomies for hallux valgus deformity. This was achieved by comparing pooled data of 2,834 operated feet. The evaluated surgical methods included proximal crescentic osteotomy, Ludloff osteotomy, proximal chevron osteotomy, proximal opening wedge osteotomy, proximal closing wedge osteotomy, and a few other proximal first metatarsal osteotomies. We found a mean correction of IMA of 8.1°. HVA showed an average improvement of 20.4°. Additionally, we evaluated the complication rate and we found a total of 18.7 %. There was a statistically significant difference concerning reduction of HVA and overall major complications between the different surgical methods. Overall and minor complications differed statistically significantly between the methods.

There are some limitations associated with this study. First, a direct comparative meta-analysis of the different methods was not possible due to the fact that there were few head-to-head studies. Therefore, we were only able to perform a pooled meta-analysis across all studies. Second, the quality of meta-analysis depends on the quality of the studies included. In our analysis the majority of included studies were uncontrolled case series. This is not uncommon in clinical musculoskeletal research. However, it illustrates the need for further prospective comparative studies. Basically, proximal osteotomies are recommended for the treatment of moderate to severe deformities [3, 5–7]. The studies included in this meta-analysis also contained patients who suffered from mild to moderate hallux valgus deformity. Therefore, the comparison of corrective power might be affected.

In this study, proximal crescentic osteotomy revealed the best results in terms of correction of HVA (23.3°) followed by Ludloff osteotomy (22.4°) and proximal chevron osteotomy (21.0°). Opening and closing wedge osteotomies provided less HVA correction. In fact, it was 16.2 and 19.6°, respectively. For IMA correction, proximal crescentic

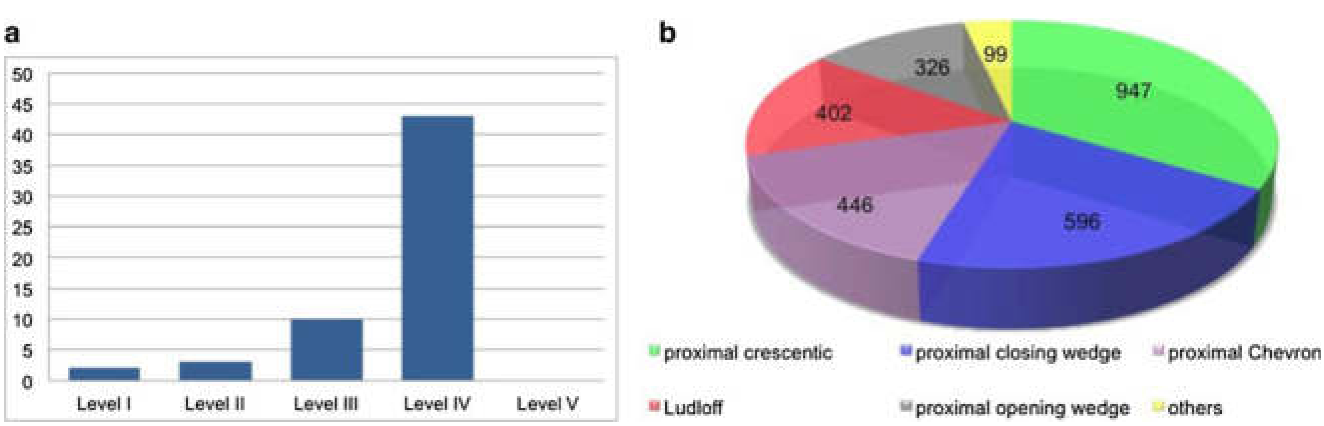


Fig. 4 **a** Number of studies for different levels of evidence. **b** Number of feet for each surgical method

osteotomy revealed the most favourable results with a mean correction of 9.2°, followed by proximal chevron, opening wedge and Ludloff osteotomies (8.2°). Proximal closing wedge osteotomy and other methods accomplished less angular correction (7.2°). However, changes in IMA were not statistically significant.

The heterogeneity between studies (compare the I^2 values and the forest plots) is considerably large. This indicates that beyond the mean differences between surgical methods, the outcome may strongly depend on further factors that vary between study areas.

In a recent meta-analysis Smith et al. [1] investigated the corrective power of distal chevron and Scarf osteotomy, respectively. For the distal chevron osteotomy, they found in 1,028 feet a mean correction of IMA of 5.33°. Analysis of 300 feet that underwent Scarf osteotomy showed a mean correction of IMA of 6.21°. The difference was statistically significant. With a mean correction of 8.2° (range 7.2–9.6°), the results of our study indicate that proximal osteotomies provide a higher corrective power than distal or diaphyseal osteotomies. This represents the clinical proof for the mathematical theory.

In one of the few comparative studies on this topic Easley et al. [22] prospectively investigated proximal crescentic and proximal chevron osteotomies in patients (84 feet) with moderate to severe deformity. According to this meta-analysis they found no statistically significant difference in correction of IMA. However, chevron osteotomy showed shorter healing time and less dorsiflexion malunion. This also corresponds to the results of this study in which proximal chevron osteotomy showed the lowest number of major complications. The difference of this parameter was significant compared to the other proximal first metatarsal osteotomies.

Recently, Park et al. compared proximal and distal chevron osteotomies in 77 feet [69]. In contrast to the results of our study compared with the meta-analysis of Smith et al. they found no statistically significant difference for correction of HVA and IMA. However, there was more shortening in the distal chevron osteotomy group. The radiographic results in terms of corrective power might be affected due to the circumstance that not only severe deformities had been included.

With 6.1 %, proximal chevron osteotomy showed the lowest rate of major complications in our study. It was followed by proximal crescentic osteotomy (11.7 %), proximal opening wedge osteotomy (14.3 %), proximal closing wedge osteotomy (15.7 %), Ludloff osteotomy (17.5 %) and the other osteotomies (24.2 %). The differences were statistically significant. The overall complication rate in proximal chevron osteotomy (11.2 %) also revealed the most favourable results compared to other osteotomies. However, these differences were not statistically significant.

The method of fixation is an important issue in PMO due to the high lever forces acting on the osteotomy site and the risk of dorsiflexion malunion. This is associated with functional impairments in terms of transfer metatarsalgia. In contrast to the clinical literature, many studies exist that compare different methods of fixation in PMO. Scott et al. compared construct stability of locking plate fixation for proximal chevron osteotomy with Ludloff osteotomy fixed with two screws and found superior results for the Ludloff construct [70]. Hofstaetter et al. found that construct stiffness of proximal opening wedge osteotomy fixed with a plate is inferior to Ludloff osteotomy with screw fixation. For proximal crescentic osteotomy dorsal plate fixation provides more stability than single screw fixation [71]. These results indicate that rigid fixation is biomechanically important for proximal osteotomies [70, 72]. In our study, we found statistically significant differences with respect to method of fixation. Pin fixation revealed inferior results concerning complications compared to more rigid methods of fixation. Plate and locking plate fixation, however, showed the most favourable results. Therefore, the latter should be recommended as the method of fixation of first metatarsal osteotomies.

This study exposed the major lack of objective, prospective and controlled data on either procedure. The findings demonstrate that the majority of available data on the results of these procedures are based on retrospective uncontrolled case series. The sample sizes in many of the studies were small and follow-up period limited. Therefore, prospective studies are needed to compare the procedures in similar patient groups.

Conclusion

To the best of our knowledge, this is the first meta-analysis on corrective power and complications of proximal first metatarsal osteotomies for hallux valgus deformity. The results of this study indicate that proximal first metatarsal osteotomies achieve a correction of IMA of 8.1° and a correction of HVA of 20.1°. The overall complication rate is 18.7 %. The proximal crescentic osteotomy provided the highest amount of HVA correction. However, regarding angular correction as well as complications the proximal chevron osteotomy revealed the most favourable results. Rigid fixation is mandatory in order to reduce complications, and further high-quality prospective comparative studies are required and might change the observed effects.

References

1. Smith SE et al (2012) Scarf versus chevron osteotomy for the correction of 1–2 intermetatarsal angle in hallux valgus: a systematic review and meta-analysis. J Foot Ankle Surg 51:437–444
2. Easley ME, Trnka HJ (2007) Current concepts review: hallux valgus part 1: pathomechanics, clinical assessment, and nonoperative management. Foot Ankle Int 28:654–659

3. Trnka HJ (2005) Osteotomies for hallux valgus correction. Foot Ankle Clin 10:15–33
4. Sammarco VJ, Acevedo J (2001) Stability and fixation techniques in first metatarsal osteotomies. Foot Ankle Clin 6:409–432
5. Robinson AH, Limbers JP (2005) Modern concepts in the treatment of hallux valgus. J Bone Joint Surg Br 87:1038–1045
6. Nyska M et al (2002) Proximal metatarsal osteotomies: a comparative geometric analysis conducted on sawbone models. Foot Ankle Int 23:938–945
7. Wagner E, Ortiz C (2012) Osteotomy considerations in hallux valgus treatment: improving the correction power. Foot Ankle Clin 17:481–498
8. Easley ME, Trnka HJ (2007) Current concepts review: hallux valgus part II: operative treatment. Foot Ankle Int 28:748–758
9. Wright JG. Levels of evidence and grades of recommendations: an evaluation of literature. American Academy of Orthopaedic Surgeons (AAOS)
10. Viechtbauer W (2010) Learning from the past: refining the way we study treatments. J Clin Epidemiol 63:980–982
11. Bar-David T, Trepal MJ (1991) A retrospective analysis of distal Chevron and Basilar osteotomies of the first metatarsal for correction of intermetatarsal angles in the range of 13 to 16 degrees. J Foot Surg 30:450–456
12. Cedell CA, Aström M (1982) Proximal metatarsal osteotomy in hallux valgus. Acta Orthop Scand 53:1013–1018
13. Chiang CC et al (2012) Distal linear osteotomy compared to oblique diaphyseal osteotomy in moderate to severe hallux valgus. Foot Ankle Int 33:479–486
14. Chiodo CP, Schon LC, Myerson MS (2004) Clinical results with the Ludloff osteotomy for correction of adult hallux valgus. Foot Ankle Int 25:532–536
15. Choi WJ et al (2009) Comparison of the proximal chevron and Ludloff osteotomies for the correction of hallux valgus. Foot Ankle Int 30:1154–1160
16. Chow FY et al (2008) Plate fixation for crescentic metatarsal osteotomy in the treatment of hallux valgus: an eight-year followup study. Foot Ankle Int 29:29–33
17. Cooper MT et al (2007) Proximal opening-wedge osteotomy of the first metatarsal for correction of hallux valgus. Surg Technol Int 16:215–219
18. Coughlin MJ, Grimes S (2005) Proximal metatarsal osteotomy and distal soft tissue reconstruction as treatment for hallux valgus deformity. Keio J Med 54:60–65
19. Coughlin MJ, Jones CP (2007) Hallux valgus and first ray mobility. A prospective study. J Bone Joint Surg Am 89:1887–1898
20. Day T, Charlton TP, Thordarson DB (2011) First metatarsal length change after basilar closing wedge osteotomy for hallux valgus. Foot Ankle Int 32:S513–S518
21. Dreeben S, Mann RA (1996) Advanced hallux valgus deformity: long-term results utilizing the distal soft tissue procedure and proximal metatarsal osteotomy. Foot Ankle Int 17:142–144
22. Easley ME et al (1996) Prospective, randomized comparison of proximal crescentic and proximal chevron osteotomies for correction of hallux valgus deformity. Foot Ankle Int 17:307–316
23. Fadel GE et al (2008) Fixation of first metatarsal basal osteotomy using Acutrak screw. Foot Ankle Surg 14:21–25
24. Fox IM, Caffiero L, Pappas E (1999) The crescentic first metatarsal basilar osteotomy for correction of metatarsus primus varus. J Foot Ankle Surg 38:203–207
25. Gallentine JW, Deorio JK, Deorio MJ (2007) Bunion surgery using locking-plate fixation of proximal metatarsal chevron osteotomies. Foot Ankle Int 28:361–368
26. Glover JP et al (2008) Early results of the Mau osteotomy for correction of moderate to severe hallux valgus: a review of 24 cases. J Foot Ankle Surg 47:237–242
27. Granberry WM, Hickey CH (1995) Hallux valgus correction with metatarsal osteotomy: effect of a lateral distal soft tissue procedure. Foot Ankle Int 16:132–138
28. Haas Z et al (2007) Maintenance of correction of first metatarsal closing base wedge osteotomies versus modified Lapidus arthrodesis for moderate to severe hallux valgus deformity. J Foot Ankle Surg 46:358–365
29. Hofstaetter SG et al (2006) The modified ludloff osteotomy for correction of severe metatarsus primus varus with hallux valgus deformity. Z Orthop Ihre Grenzgeb 144(2):141–147
30. Hyer CF et al (2008) A comparison of the crescentic and Mau osteotomies for correction of hallux valgus. J Foot Ankle Surg 47:103–111
31. Jensen NC, Søballe K, Christiansen SE (1989) Correction of hallux valgus and metatarsus primus varus. Using the Cedell technique. Orthopedics 12:421–424
32. Lee KB et al (2009) Outcome of unilateral versus simultaneous correction for hallux valgus. Foot Ankle Int 30:120–123
33. Lee KB et al (2008) Outcome of proximal chevron osteotomy for hallux valgus with and without transverse Kirschner wire fixation. Foot Ankle Int 29:1101–1106
34. Lee WC, Kim YM (2007) Correction of hallux valgus using lateral soft-tissue release and proximal Chevron osteotomy through a medial incision. J Bone Joint Surg Am 89:82–89
35. Limbird TJ, DaSilva RM, Green NE (1989) Osteotomy of the first metatarsal base for metatarsus primus varus. Foot Ankle 9:158–162
36. Lüthje P (1990) Long-term results of proximal metatarsal osteotomy in hallux valgus. J Am Podiatr Med Assoc 80:304–306
37. Mann RA, Rudicel S, Graves SC (1992) Repair of hallux valgus with a distal soft-tissue procedure and proximal metatarsal osteotomy. A long-term follow-up. J Bone Joint Surg Am 74:124–129
38. Markbreiter LA, Thompson FM (1997) Proximal metatarsal osteotomy in hallux valgus correction: a comparison of crescentic and chevron procedures. Foot Ankle Int 18:71–76
39. Nedopil A et al (2010) Closed wedge osteotomy in 66 patients for the treatment of moderate to severe hallux valgus. Foot Ankle Surg 16:9–14
40. Okuda R et al (2000) Distal soft tissue procedure and proximal metatarsal osteotomy in hallux valgus. Clin Orthop Relat Res 379:209–217
41. Okuda R et al (2005) Proximal metatarsal osteotomy: relation between 1- to greater than 3-years results. Clin Orthop Relat Res 435:191–196
42. Okuda R et al (2008) Proximal metatarsal osteotomy for hallux valgus: comparison of outcome for moderate and severe deformities. Foot Ankle Int 29:664–670
43. Paczesny L, Kruczyński J, Adamski R (2009) Scarf versus proximal closing wedge osteotomy in hallux valgus treatment. Arch Orthop Trauma Surg 129:1347–1352
44. Pearson SW et al (1991) Results and complications following a proximal curved osteotomy of the hallux metatarsal. Contemp Orthop 23:127–132
45. Pehlivan O et al (2004) Proximal oblique crescentic osteotomy in hallux valgus. J Am Podiatr Med Assoc 94:43–46
46. Petratos DV et al (2008) Correction of adolescent hallux valgus by proximal crescentic osteotomy of the first metatarsal. Acta Orthop Belg 74:496–502
47. Randhawa S, Pepper D (2009) Radiographic evaluation of hallux valgus treated with opening wedge osteotomy. Foot Ankle Int 30:427–431
48. Resch S, Stenström A, Egund N (1989) Proximal closing wedge osteotomy and adductor tenotomy for treatment of hallux valgus. Foot Ankle 9:272–280
49. Ritschl P et al (1999) Hallux valgus: a therapy concept and its outcome from 1993 to 1996. Z Orthop Ihre Grenzgeb 137:521–527
50. Robinson AH et al (2009) Prospective comparative study of the scarf and Ludloff osteotomies in the treatment of hallux valgus. Foot Ankle Int 30:955–963

51. Sammarco GJ, Brainard BJ, Sammarco VJ (1993) Bunion correction using proximal Chevron osteotomy. Foot Ankle 14:8–14
52. Sammarco GJ, Russo-Alesi FG (1998) Bunion correction using proximal chevron osteotomy: a single-incision technique. Foot Ankle Int 19:430–437
53. Saragas NP (2009) Proximal opening-wedge osteotomy of the first metatarsal for hallux valgus using a low profile plate. Foot Ankle Int 30:976–980
54. Seiberg M, et al (1994) 1994 William J. Stickel Silver Award. Closing base wedge versus Austin bunionectomies for metatarsus primus adductus. J Am Podiatr Med Assoc 84:548–563
55. Señarís-Rodríguez J et al (1998) Surgical treatment for bunions in adolescents. J Pediatr Orthop B 7:210–216
56. Shurnas PS, Watson TS, Crislip TW (2009) Proximal first metatarsal opening wedge osteotomy with a low profile plate. Foot Ankle Int 30:865–872
57. Smith WB et al (2009) Opening wedge osteotomies for correction of hallux valgus: a review of wedge plate fixation. Foot Ankle Spec 2:277–282
58. Takao M et al (2007) Proximal oblique-domed osteotomy of the first metatarsal for the treatment of hallux valgus associate with flat foot: effect to the correction of the longitudinal arch of the foot. Arch Orthop Trauma Surg 127:685–690
59. Tanaka Y et al (2008) Proximal spherical metatarsal osteotomy for the foot with severe hallux valgus. Foot Ankle Int 29:1025–1030
60. Thordarson DB, Leventen EO (1992) Hallux valgus correction with proximal metatarsal osteotomy: two-year follow-up. Foot Ankle 13:321–326
61. Treadwell JR (2005) Rail external fixation for stabilization of closing base wedge osteotomies and lapidus procedures: a retrospective analysis of sixteen cases. J Foot Ankle Surg 44:429–436
62. Trnka HJ et al (2008) Intermediate-term results of the Ludloff osteotomy in one hundred and eleven feet. J Bone Joint Surg Am 90:531–539
63. Trnka HJ et al (1999) Basal closing wedge osteotomy for correction of hallux valgus and metatarsus primus varus: 10- to 22-year follow-up. Foot Ankle Int 20:171–177
64. Veri JP, Pirani SP, Claridge R (2001) Crescentic proximal metatarsal osteotomy for moderate to severe hallux valgus: a mean 12.2 year follow-up study. Foot Ankle Int 22:817–822
65. Walther M et al (2008) The proximal open-wedge osteotomy with interlocking plate for correction of splayfoot deformities with hallux valgus. Oper Orthop Traumatol 20:452–462
66. Wukich DK, Roussel AJ, Dial DM (2009) Correction of metatarsus primus varus with an opening wedge plate: a review of 18 procedures. J Foot Ankle Surg 48:420–426
67. Zembsch A et al (1998) Long-term results of basal wedge osteotomy in metatarsus primus varus in the young patient. Z Orthop Ihre Grenzgeb 136:243–249
68. Zettl R et al (2000) Moderate to severe hallux valgus deformity: correction with proximal crescentic osteotomy and distal soft-tissue release. Arch Orthop Trauma Surg 120:397–402
69. Park CH et al (2013) A comparison of proximal and distal chevron osteotomy for the correction of moderate hallux valgus deformity. Bone Joint J 95:649–656
70. Scott AT et al (2010) Biomechanical comparison of hallux valgus correction using the proximal chevron osteotomy fixed with a medial locking plate and the Ludloff osteotomy fixed with two screws. Clin Biomech (Bristol, Avon) 25:271–276
71. Varner KE et al (2009) Screw versus plate fixation of proximal first metatarsal crescentic osteotomy. Foot Ankle Int 30:142–149
72. Hofstaetter SG et al (2008) Biomechanical comparison of screws and plates for hallux valgus opening-wedge and Ludloff osteotomies. Clin Biomech (Bristol, Avon) 23:101–108

AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International®
2015, Vol. 36(11) 1322–1329

DOI: 10.1177/1071100715593082
fai.sagepub.com

Role of a Limited Transarticular Release in Severe Hallux Valgus Correction

Emilio Wagner, MD[1], Cristian Ortiz, MD[1], Francisco Figueroa, MD[1], Omar Vela, MD[2], Pablo Wagner, MD[1], and John S. Gould, MD[3]

Abstract

Background: Hallux valgus (HV) treatment is continuously evolving, and no definitive treatment can be recommended. Osteotomies are the main surgical choice for these deformities, but no clear role for soft tissue procedures is available. Objective: To perform a retrospective comparison of the radiographic and clinical outcomes of 2 groups of patients with severe HV operated with the same osteotomy technique but differing on the type of lateral release.
Methods: Two groups of patients with symptomatic moderate to severe HV deformities were operated with the same proximal metatarsal osteotomy, which differed on the type of lateral release: group 1 had limited transarticular lateral capsule release (n = 62), and group 2 complete lateral release, including capsule, adductor tendon, and intermetatarsal (IM) ligament (n = 57). We recorded the American Orthopaedic Foot & Ankle Society (AOFAS) score, HV and IM angles, first metatarsal shortening, concomitant metatarsal shortening osteotomies (Weil), Akin osteotomies, and complications.
Results: The postoperative AOFAS score in group 1 was similar to that of group 2. The HV and IM angles improved in both groups with no significant difference. The multivariate analysis showed no influence of any variable analyzed on HV or IM angle improvement. Regarding AOFAS score improvement, a limited lateral release was associated with a higher increase in AOFAS score ($P = .019$).
Conclusion: No studies are available to identify which soft tissue structures are involved in HV deformities nor which have to be released, if any. A limited transarticular release can provide similar clinical and radiologic outcomes when compared with a classic open lateral release.
Level of Evidence: Level IV, case series.

Keywords: hallux valgus, limited transarticular release, complete lateral release, American Orthopaedic Foot & Ankle Society score, intermetatarsal angle

Hallux valgus (HV) treatment has been evolving for decades and still is a subject of controversy. The lack of clear understanding of its pathophysiology, grading of severity, and ideal method of treatment explains why more than 100 surgical techniques are available with regard to soft tissue releases and repair techniques. Current literature supports the use of osteotomies as the main choice in treatment,[11] but information is scarce that deals with the extent or absolute need for lateral metatarsophalangeal (MTP) soft tissue release. The reasoning behind a lateral soft tissue release is twofold: soft tissues may represent an obstacle in reducing the MTP joint, and these tissues contract over time. In the literature, there is no available information examining which structures are contracted, if any. Classically,[3] a lateral release should include the MTP capsule as well as the metatarsosesamoid ligament, adductor tendon, and intermetatarsal (IM) ligament. Recent studies showed good results in cases of mild and moderate HV treated with distal osteotomies with lateral release[12] and without.[6] For severe HV deformities treated with osteotomies or first tarsometatarsal fusions, good results have been shown with distal osteotomies and classic dorsal open lateral releases, as well as with limited transarticular releases, which include the adductor tendon. These good results—with the idea that the key for success in HV treatment is to relocate the metatarsal head over the sesamoid complex—may suggest that the lateral soft tissue release is not as important as classically believed. No information is available relative to which soft tissue release is needed in severe HV deformities treated with

[1]Clínica Alemana-Universidad del Desarrollo, Santiago, Chile
[2]Traumatology and orthopedic surgeon, Monterrey, Mexico
[3]Division of Orthopaedic Surgery, University of Alabama at Birmingham, Birmingham, AL, USA

Corresponding Author:
Pablo Wagner, MD, Clínica Alemana-Universidad del Desarrollo, Vitacura 5951, Santiago, Chile.
Email: pwagner@alemana.cl

Table 1. Preoperative Characteristics of Groups 1 and 2.[a]

Characteristic	Group 1 (Transarticular)	Group 2 (Dorsal Open)	*P* Value
n	62	57	
Age, y	55.3 ± 16.3	53.8 ± 16.6	.610
HV angle, degrees	35.9 ± 7.7 (23-56)	37.1 ± 8.3 (22-55)	.410
IM angle, degrees	15.5 ± 2.7 (9-22)	14.3 ± 3.8 (5-23)	.030
AOFAS score	47.6 ± 9.7	58.2 ± 8.4	.0004

Abbreviations: HV, hallux valgus; IM, intermetatarsal.
[a]Values presented as mean ± SD (range).

proximal osteotomies. No study is available which reports on severe HV deformities treated with osteotomies and a limited lateral capsular release.

The objective of this study was to compare clinical and radiologic results of severe HV deformity patients treated with a proximal osteotomy and 2 types of lateral release—a limited transarticular lateral capsular release versus a complete lateral release through a separate dorsal incision. Our hypothesis was that there would be no differences between the 2 groups studied.

Methods

We performed a retrospective review of 2 clinical series in 2 centers operated between May 2005 and August 2009, with a clinical diagnosis of symptomatic HV and a minimum clinical follow-up of 2 years (average, 44 months). Inclusion criteria were symptomatic moderate to severe HV deformity (more than 11 degrees of IM angle or 30 degrees of MTP angle), no significant restriction (less than 30 degrees dorsiflexion) in the first MTP joint movement, and no degenerative changes in the first MTP or the tarsometatarsal joints (on preoperative radiographs). Patients with inflammatory arthritis, gout, poor skin quality, and poor circulation were excluded. The preoperative information used in the study, as well as for the American Orthopaedic Foot & Ankle Society (AOFAS) score, included range of motion of the first MTP joint and radiographic analysis, and such data were obtained and calculated retrospectively from clinical information in the patients' medical records.

Standard weight-bearing anteroposterior, oblique, and lateral radiographs were taken of each foot. Measurements were done according to Coughlin et al.[4] All patients undergoing surgery in one center were assigned to group 1, and all patients undergoing surgery in the second center were assigned to group 2, differing in the type of lateral release performed. This difference was due to the surgical protocol followed in each center, which differed only in the type of soft tissue release. Every surgery was performed by a fellowship-trained foot and ankle surgeon. Group 1 consisted in 62 patients (60 women, 2 men) treated with a POSCOW osteotomy (ie, proximal oblique slide closing wedge osteotomy)[13] and a transarticular lateral release, including only the lateral MTP capsule and metatarsosesamoid ligament. Group 2 consisted of 57 patients (51 women, 6 men) treated with a POSCOW osteotomy and a complete lateral release, including capsule, adductor tendon, and IM ligament performed through a separate dorsal first web release. The characteristics of both groups are summarized in Table 1. There were no statistically significant differences in age (group 1 vs group 2: 55 vs 53 years, $P = .6$) or HV angle (group 1 vs group 2: 35.8 vs 37.1 degrees, $P = .4$). Group 1 had a greater preoperative IM angle than that of group 2 (15.4 vs 14.2 degrees, $P = .020$) and a lower preoperative AOFAS score (47.5 vs 58.2, $P = .001$). Group 1 had a longer postoperative follow-up (51 vs 39 months, $P = .0004$; minimum, 26 months in both groups). We recorded for both groups the AOFAS postoperative score, postoperative change in HV and IM angle, first metatarsal shortening, concomitant metatarsal shortening osteotomies performed for metatarsalgia, Akin osteotomies, loss of correction, and complications after the surgery. Loss of correction was defined as any change in angular correction noticed by either the patient or the surgeon, clinically or radiologically. Complications included any malunion, nonunion, infection, hallux varus, hardware irritation, or reoperation for any reason. Every measurement (HV or IM angle or metatarsal length) was performed by 2 independent reviewers (blinded to which type of lateral release was performed at the time of the surgery) on digital weight-bearing feet X-rays, obtained at the last clinical follow-up. The *t* test compared the continuous variables with normal distribution and the Fisher exact test of independence, the categorical variables. A multivariate analysis was performed to analyze the influence on HV or IM angle improvement and AOFAS score improvement for the following variables: age, shortening of first metatarsal, reoperation for any reason, infection, follow-up, presence of Weil or Akin osteotomy, and type of lateral release.

Surgical Technique

A medial longitudinal incision was made from the first tarsometatarsal joint to just proximal to the interphalangeal

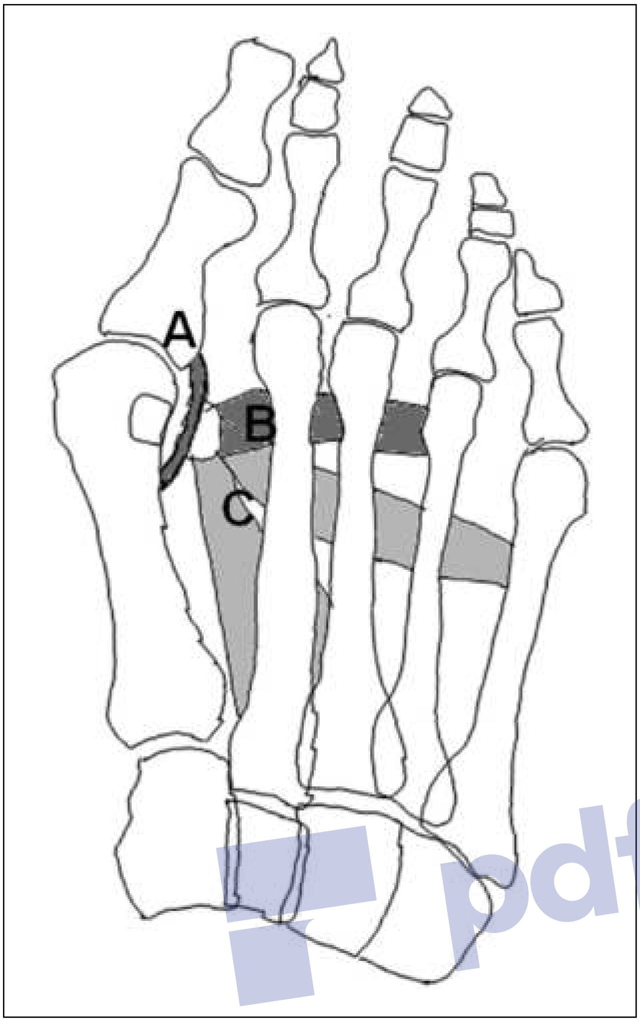


Figure 1. Diagram of right foot identifying structures to be released: A, the lateral metatarsophalangeal capsule and metatarsosesamoid ligament; B, the intermetatarsal ligament; C, the adductor tendon.

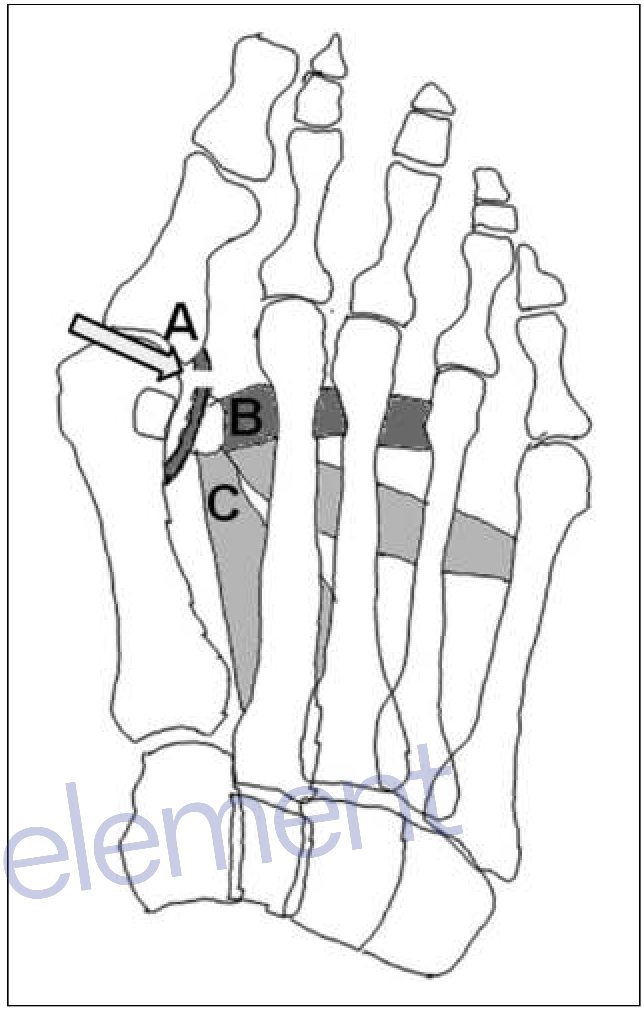


Figure 2. Diagram of right foot identifying structures released (A-C, see Figure 1). Arrow indicates transarticular release of lateral metatarsophalangeal capsule and metatarsosesamoid ligament.

joint. An inverted L capsulotomy was performed exposing the MTP joint and proximal metatarsal. The first metatarsal was exposed and dissected subperiosteally, leaving the lateral and plantar distal area intact to preserve circulation. The MTP joint was inspected with osteophytes excised, and drilling was carried out for any denuded cartilage area. A resection of the medial eminence (superficial to the sagittal groove) was performed.

Regarding the lateral release, it was always performed before the osteotomy. In 62 patients (group 1) an intra-articular lateral release was performed, taking care to release only the capsule and metatarsosesamoid ligament just dorsal to the lateral sesamoid (Figures 1 and 2). This release was performed by manually distracting the MTP joint just enough to place the surgical blade inside the joint from medial to lateral. After this, the lateral capsule was released from the dorsal aspect of the lateral sesamoid to the dorsolateral corner of the metatarsal bone. We then manually exerted a varus force on the hallux to percutaneously tear the rest of the MTP capsule. The extent of the release was tailored to each case to easily manually realign the hallux in relation to the first metatarsal. In 57 patients (group 2) a 1-2 IM web release was performed, releasing the lateral MTP capsule, the IM ligament, and the adductor hallucis attachment to the lateral side of the lateral sesamoid (Figure 3), achieving the same goal as in the limited release group—that is, an easy realignment of the hallux in relation to the first metatarsal.

A POSCOW osteotomy (Figure 4) was performed as previously described,[13] achieving a lateral displacement and lateral closing wedge effect to leave the first metatarsal parallel to the second metatarsal. Fixation was performed

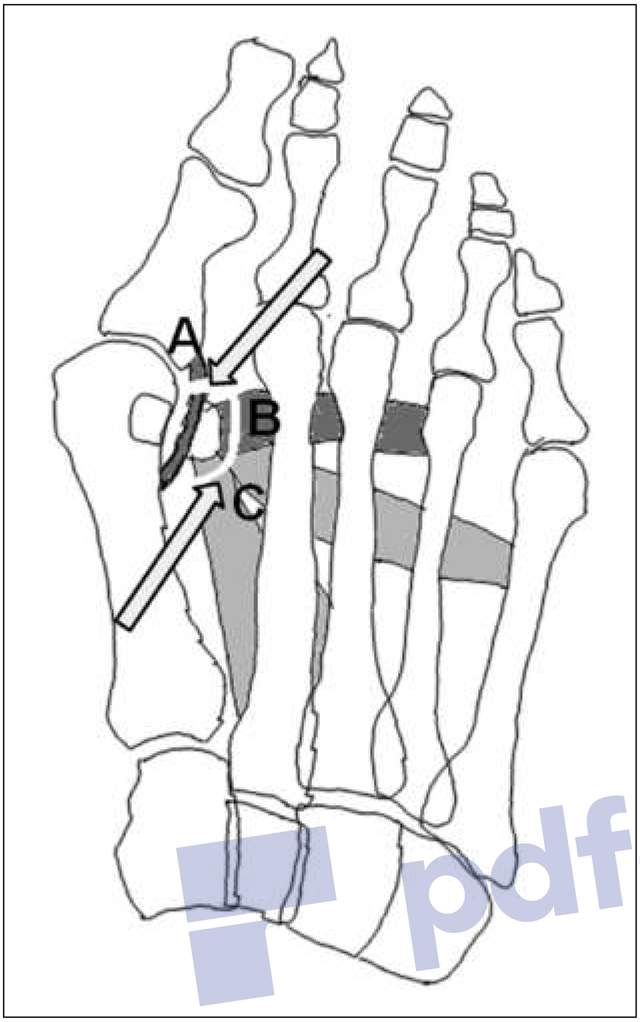


Figure 3. Diagram of right foot identifying structures released (A-C, see Figure 1). Arrows indicate open release of lateral metatarsophalangeal capsule and metatarsosesamoid ligament, intermetatarsal ligament, and adductor tendon.

either with a minifragment plate, initially placed on the dorsal side of the metatarsal on the first 32 cases in group 1 or with a medial locked plate in the rest of the series. Fluoroscopy was used to assess parallelism of the first and second metatarsals previous to fixation. Capsulorrhaphy was performed with 2-0 absorbable suture. The subcuticular layer was closed with 4-0 absorbable suture and the skin with 4-0 nylon suture.

Postoperative Course

The patients were placed in a soft bulky dressing with no pressure on or specific splinting of the great toe. A fiberglass cast (which was bivalved in the operating room) was applied over the dressing. The patients were mainly non–weight bearing (if a cast was applied) or weight bearing over the lateral side of the foot (if immediate use of a postoperative stiff sole shoe was indicated). At 2 weeks, the sutures were removed, and the patients were weight bearing as tolerated in an orthopedic wedge shoe or stiff-sole shoe, which was used for weight bearing up to the 6-week interval. After this period, every patient started using a regular sports shoe or any shoe that fit depending on edema. No difference in postoperative protocol existed between groups.

Results

The postoperative AOFAS score in group 1 was similar to that in group 2 ($P > .05$). There was no difference between groups regarding the average improvement in HV angle (average change in HV angle, group 1 vs group 2: –24.8/–26, $P = .6$) or IM angle (average change in IM angle, group 1 vs group 2: –9/–11, $P = .2$). These results are summarized in Table 2. There was a strong correlation between the final postoperative IM angle and the final HV angle ($r = 0.61$).

Regarding metatarsal shortening, the average decrease in length of the first metatarsal was 2 mm greater in group 1 vs group 2 (3.8 vs 1.5 mm, $P = .0001$). Metatarsal shortening osteotomy (Weil) and Akin osteotomy were more frequently used in group 1 (n = 31 of 62, $P = .018$; n = 13 of 62, $P = .00001$) than in group 2 (9 and 3 of 57 cases, respectively). The reoperation rate for symptomatic hardware, postoperative varus, loss of correction, and infection showed no difference between groups. Complications are summarized in Table 3.

Based on multivariate analysis—with the end points being HV and IM angle improvement—no statistically significant influence was observed regarding age, type of lateral release, presence of Weil or Akin osteotomy, shortening, reoperation for any reason, or follow-up. When AOFAS score improvement was analyzed, no influence was detected for any variable, except type of lateral release and presence of infection. A limited lateral release was associated with a higher increase in AOFAS score ($P = .019$), and the presence of infection was associated with a decrease in AOFAS score ($P = .002$). The multivariate analysis for AOFAS score improvement is shown in Table 4.

Discussion

A lateral sesamoidectomy was used in the first half of last century as part of the concept of creating space and eliminating any obstacle to reduction of the incongruent MTP joint, but it has been mostly abandoned due to reports of complications, including iatrogenic hallux varus, scarring, and lateral plantar hallucal nerve damage.[1] A lateral release of the adductor tendon and the IM ligament was thought to be necessary due to contracture of soft tissues after a longstanding deformity.[3] No real evidence relative to which

Figure 4. Preoperative (a) and postoperative (b) clinical image and weight-bearing X-ray of hallux valgus patient operated with proximal oblique slide closing wedge osteotomy.

Table 2. Postoperative Characteristics of Groups 1 and 2.

Group	Group 1 (Transarticular)	Group 2 (Dorsal Open)	*P* Value
HV angle, degrees	12 ± 8.3 (0 to 31)	10.9 ± 10 (–13 to 43)	
Difference vs preoperative	–25 ± 8.1	–26 ± 14	.6
IM angle, degrees	6.1 ± 3.6 (0 to 15)	3.1 ± 3.7 (–3 to 13)	
Difference vs preoperative	–9.8 ± 4	–11 ± 5	.2
AOFAS score	84 ± 7.7	86.7 ± 14.4	
Difference vs preoperative	36 ± 11	28.5 ± 15.7	.004
Shortening, mm	3.9 ± 0.27	1.5 ± 0.24	.0004
Loss of correction not needing surgery, No.[b]	9	10	.6
Superficial infection, No.[b]	2	0	.22
Follow-up, mo (p50)	51	39	.0004

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; HV, hallux valgus; IM, intermetatarsal; p50, 50th percentile.
[a]Values presented as mean ± SD (range), unless noted otherwise.
[b]No. of cases.

Table 3. Reoperation for Any Reason: Groups 1 and 2.[a]

Reason	Group 1 (Transarticular)	Group 2 (Dorsal Open)	*P* Value
Symptomatic hardware	11	10	.4
Varus	0	2	.27
Loss of correction	1	6	.07

[a]Values presented as number of cases.

Table 4. Multivariate Analysis for American Orthopaedic Foot & Ankle Society Score Improvement.

Improvement	Coefficient	SE	*t*	*P* > *t*	95% Confidence Interval	
Age	0.010	0.106	0.09	.925	–0.200	0.220
Shortening	0.874	0.862	1.01	.314	–0.841	2.589
Reop ots[a]	–2.433	4.295	–0.57	.573	–10.976	6.111
Reop varus[b]	8.504	14.926	0.57	.570	–21.188	38.196
Infection	–33.740	10.331	–3.27	.002	–54.292	–13.188
Follow-up	0.185	0.240	0.77	.443	–0.292	0.662
Weil	–0.144	3.593	–0.04	.968	–7.292	7.003
Akin	–5.154	4.913	–1.05	.297	–14.928	4.620
Limited release[c]	10.251	4.278	2.40	.019	1.742	18.760
Complete release[d]	–5.890	7.600	–0.77	.441	–21.009	9.229
Constant	19.889	11.898	1.67	.098	–3.781	43.557

[a]Reoperation due to hardware irritation.
[b]Reoperation due to varus.
[c]Group 1 only.
[d]Group 2 only.

structures are contracted in HV is available in the published literature. It could be expected that if the adductor tendon was to exert some action due to its contracture, some change in sesamoid position could be found in radiologic studies, as it has been determined that the adductor tendon inserts onto the lateral sesamoid exclusively.[7] On the contrary, it has been shown in different studies that the sesamoid complex does not change its position in HV deformities, nor does the position of the base of the proximal phalanx.[9,10] It can be suggested from this information that the adductor tendon plays no role in the medial deviation of the metatarsal bone or on the lateral deviation of the hallux and, thus, on HV deformity. Therefore, releasing the adductor tendon may have no role in the treatment of HV deformities.

In analyzing which structures may need to be released in HV surgery, some clinical studies have been already published. Lee et al[6] showed that for mild to moderate HV deformities, adding a lateral release did not produce any statistically significant postoperative change in HV angle, IM angle, or AOFAS score. They also showed that releasing lateral structures was associated with less postoperative range of motion of the MTP joint, digital neuritis, and dorsal web space scarring. Park et al[8] compared a limited transarticular approach versus a dorsal first web space approach combined with a distal chevron osteotomy. The only structure not released through the limited approach was the IM ligament, achieving release of the capsule and adductor tendon in both groups. There was no clinical and radiographic outcome difference between the groups.

In our study, we compared similar HV cases operated on by trained foot and ankle surgeons in 2 centers using the same osteotomy technique, differing on the type of lateral release performed. Both groups were comparable with the exception that group 1 had a higher preoperative deformity and a longer follow-up. The release performed in this group included only the lateral capsule, which was performed transarticularly, taking care not to release any other structure. At the last follow-up, this group presented a better improvement in AOFAS score (P = .019), a similar final AOFAS score (group 1 vs group 2, 84 vs 86), and similar improvements in HV and IM angles where a complete classic open lateral release was performed. The only other difference between the 2 groups was metatarsal shortening. Metatarsal shortening relates directly to the closing wedge component of the technique, where group 1 had a higher postoperative shortening than that of group 2 (3.8 vs 1.5 mm). We consider that this difference, though not desirable, has no clinical significance, as it is compensated with the slight plantarflexion component of the osteotomy.[13] These results suggest that even when severe HV deformities are treated, the most important factor for success is to relocate the metatarsal head over its anatomic position, and to do this, a lateral opening of the MTP capsule may be enough. This fact has already been suggested in the literature,[2] where performing isolated osteotomies in HV deformities with a strong-enough lateral shift of the metatarsal head reduced the majority of cases.[5] The strong correlation between the final IM and HV angles also supports the importance of properly correcting the IM angle to obtain a good result. Avoiding soft tissue dissection and consequent edema, postoperative scarring and possible clinical dissatisfaction may constitute an advantage to explain how group 1 achieved similar final clinical results when compared with group 2. No difference was found regarding complications or reoperation rate. Regarding reoperations, most cases were due to symptomatic hardware (70%). This complication occurred in the first cases operated within the series, due to the learning curve of the technique. Reoperation due to varus or recurrence was more frequent in group 2, although not statistically significant.

Limitations in our study include it being nonrandomized, as randomization would have added stronger evidence to the hypothesis. As patients were treated in 2 centers, the surgical technique utilized may differ locally and therefore alter the results. The postoperative protocol, though similar, had some local variations depending on social and personal preferences, such as availability of shoe wear and capability of allowing weight bearing. The AOFAS score is not validated, and ideally, a different outcome score should be used to compare 2 groups of patients. It is commonly used and frequently reported in clinical studies. Despite these limitations, we were able to compare 2 groups of patients with similar preoperative characteristics, surgical technique, and rehabilitation, differing mainly in the type of lateral release performed.

In this study, patients who were treated with osteotomies and only a lateral capsular release (group 1) had a worse preoperative AOFAS score and a higher preoperative IM angle; as such, it is impressive to obtain even better clinical improvement than in the group subjected to a formal open lateral release (group 2). This finding could be related to the better sense of improvement found in the more severe deformity patients, as they will observe and perceive a bigger change after the operation. In conclusion, we strongly believe that the classic approach to severe HV deformities—where a complete lateral soft tissue release was thought to be needed to achieve a good postoperative reduction and alignment of the MTP joint—is no longer true. It can be suggested that one of the most important soft tissue procedures in the surgical technique for HV deformities is to perform a lateral MTP capsulotomy wide enough to allow the metatarsal head to displace laterally and be relocated over the sesamoid complex. To our knowledge, this is the first study to consider just a limited capsular release in severe HV deformity. More studies are needed to improve our knowledge relative to soft tissue involvement in this pathology.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Amol S, Tom K. Return to activity after sesamoidectomy in athletically active individuals. *Foot Ankle Int*. 2003;24(5): 415-419.
2. Asuncion J, Poggio D. Transmetatarsal lateral release in hallux valgus surgery: technical tip. *Foot Ankle Int*. 2012;33(10):844-847.

3. Coughlin M, Speight GJ. Proximal metatarsal osteotomy and distal soft tissue reconstruction as treatment for hallux valgus deformity. *Keio J Med*. 2005;54(2):60-65.
4. Coughlin MJ, Freund E, Roger A. The reliability of angular measurements in hallux valgus deformities. *Foot Ankle Int*. 2001;22(5):369-379.
5. Esemenli T, Yildrim Y, Bezer M. Lateral shifting of the first metatarsal head in hallux valgus surgery: effect on sesamoid reduction. *Foot Ankle Int*. 2003;24(12):922-926.
6. Lee HJ, Chung JW, Chu IT. Comparison of distal chevron osteotomy with and without lateral soft tissue release for the treatment of hallux valgus. *Foot Ankle Int*. 2010;31(4):291-295.
7. Owens S, Thordarson D. The adductor hallucis revisited. *Foot Ankle Int*. 2001;22(3):186-191.
8. Park Y, Lee K, Kim S. Comparison of distal soft-tissue procedures combined with a distal chevron osteotomy for moderate to severe hallux valgus: first web-space versus transarticular approach. *J Bone Joint Surg Am*. 2013;95(21):e158.
9. Saragas N, Becker P. Comparative radiographic analysis of parameters in feet with and without hallux valgus. *Foot Ankle Int*. 1995;16(3):139-143.
10. Tanaka Y, Takakura Y, Sugimoto. Precise anatomic configuration changes in the first ray of the hallux valgus foot. *Foot Ankle Int*. 2000;21(8):651-656.
11. Trnka H. Osteotomies for hallux valgus correction. *Foot Ankle Clin N Am*. 2005;10(1):15-33.
12. Vito P, Roberto C, Pasquale F. Chevron osteotomy with lateral release and adductor tenotomy for hallux valgus. *Foot Ankle Int*. 2009;30(6):512-516.
13. Wagner E, Ortiz C, Keller A. Proximal oblique slide closing wedge (POSCOW) metatarsal osteotomy with plate fixation for severe hallux valgus deformities. *Techniques in Foot and Ankle Surgery*. 2007;6(4):270-274.

The Journal of Foot & Ankle Surgery 55 (2016) 808–811

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Comparison of the Modified McBride Procedure and the Distal Chevron Osteotomy for Mild to Moderate Hallux Valgus

Gi Won Choi, MD, PhD [1], Hak Jun Kim, MD, PhD [2], Taik Seon Kim, MD, PhD [3], Sung Kwang Chun, MD [4], Tae Wan Kim, MD [4], Yong In Lee, MD [5], Kyoung Ho Kim, MD [5]

[1] *Clinical Assistant Professor, Department of Orthopaedic Surgery, Korea University Ansan Hospital, Ansan-si, Korea*
[2] *Professor, Department of Orthopaedic Surgery, Korea University Guro Hospital, Seoul, Korea*
[3] *Orthopaedic Surgeon, Department of Orthopaedic Surgery, Veterans Health Service Medical Center, Seoul, Korea*
[4] *Orthopaedic Surgeon, Department of Orthopaedic Surgery, Korea University Guro Hospital*
[5] *Orthopaedic Surgery Resident, Department of Orthopaedic Surgery, Veterans Health Service Medical Center, Seoul, Korea*

A R T I C L E I N F O

Level of Clinical Evidence: 3

Keywords:
bunionectomy
first ray
metatarsal
proximal phalanx
soft tissue procedure

A B S T R A C T

Distal metatarsal osteotomy and the modified McBride procedure have each been used for the treatment of mild to moderate hallux valgus. However, few studies have compared the results of these 2 procedures for mild to moderate hallux valgus. The purpose of the present study was to compare the results of distal chevron osteotomy and the modified McBride procedure for treatment of mild to moderate hallux valgus according to the severity of the deformity. We analyzed the data from 45 patients (49.5%; 48 feet [49.0%]), who had undergone an isolated modified McBride procedure (McBride group), and 46 patients (50.5%; 50 feet [51.0%]), who had a distal chevron osteotomy (chevron group). We subdivided each group into those with mild and moderate deformity and compared the clinical and radiologic outcomes between the groups in relation to the severity of the deformity. The improvements in the American Orthopaedic Foot and Ankle Society scale score and the visual analog scale for pain were significantly better for the chevron group for both mild and moderate deformity. The chevron group experienced significantly greater correction in the hallux valgus angle and intermetatarsal angle for both mild and moderate deformity. The chevron group experienced a significantly greater decrease in the grade of sesamoid displacement for patients with moderate deformity. The McBride group had a greater risk of recurrence than did the chevron group for moderate deformity (odds ratio 14.00, 95% confidence interval 3.91 to 50.06, $p < .001$). The results of the present study have demonstrated the superiority of the distal chevron osteotomy over the modified McBride procedure for mild to moderate deformity. For patients with moderate deformity, the McBride group had a greater risk of hallux valgus recurrence than did the distal chevron group. Therefore, we recommend distal chevron osteotomy rather than a modified McBride procedure for the treatment of mild and moderate hallux valgus.

The selection of a procedure to treat hallux valgus deformity is determined by the severity of the deformity and the magnitude of the intermetatarsal angle (IMA) (1). For mild to moderate hallux valgus deformity, distal osteotomies of the first metatarsal or the modified McBride procedure are performed (2–4). For more severe deformity, more proximal first metatarsal osteotomies have been recommended (5).

Distal metatarsal osteotomies can effectively correct mild to moderate deformity, and the chevron osteotomy has become widely accepted (6). Some investigators have reported that an isolated modified McBride procedure without metatarsal osteotomy leads to favorable outcomes in patients with mild to moderate deformity (2,3,7). Although each of these procedures has been used to treat mild to moderate hallux valgus deformity, few studies (2,8,9) have compared the clinical and radiologic outcomes of these procedures. They all described their results without distinction regarding the severity of the deformity.

The purpose of the present study was to assess the results of distal chevron osteotomy and the modified McBride procedure for the treatment of mild to moderate hallux valgus deformity and to compare the results according to the severity of the deformity.

Patients and Methods

The hospital's institutional review board approved the present study. We retrospectively reviewed the medical records of 54 patients (57 feet) who had undergone an isolated modified McBride procedure without metatarsal osteotomy and 59 patients (63 feet) who had undergone a distal chevron osteotomy from April 2004 to November

Financial Disclosure: None reported.
Conflict of Interest: None reported.

Address correspondence to: Hak Jun Kim, MD, PhD, Department of Orthopaedic Surgery, Korea University Guro Hospital, 148 Gurodong-ro, Guro-gu, Seoul 152-703, Korea.
E-mail address: hjunkimos@gmail.com (H.J. Kim).

1067-2516/$ - see front matter
http://dx.doi.org/10.1053/j.jfas.2016.02.014

2011 for the treatment of symptomatic hallux valgus. All operations were performed by the senior author (T.S.K.), and he sequentially undertook the 2 different procedures. The modified McBride procedures were performed in the first half of the present study, and distal chevron osteotomies were performed in the second half. The inclusion criteria were a painful bunion and hallux valgus deformity refractory to nonoperative management, mild to moderate hallux valgus with an incongruent first metatarsophalangeal joint, the availability of dorsoplantar weightbearing radiographs of the feet that had been taken preoperatively and at the final follow-up visit, and a minimum follow-up period of 2 years. The exclusion criteria were hallux rigidus, rheumatoid arthritis, previous failed hallux valgus surgery, and combined procedures other than the distal chevron osteotomy or the modified McBride procedure. In all, 9 patients (8.0%) were lost to follow-up, and 13 patients (11.5%) were excluded from the study: 3 patients (2.7%) with rheumatoid arthritis, 1 (0.9%) with failed previous surgery, and 9 (8.0%) who had undergone combined procedures other than the index procedures. A total of 91 patients (98 feet; 80.5% of the potentially eligible patients and 81.7% of the potentially eligible feet) were finally enrolled in the present study. The patients were divided into 2 groups according to the surgical technique: 45 patients (49.5%; 48 feet [49.0%]) had undergone an isolated modified McBride procedure (McBride group) and 46 patients (50.5%; 50 feet [51.0%]) had undergone distal chevron osteotomy (chevron group). In accordance with Coughlin (1), we subdivided each group into those with mild (hallux valgus angle [HVA] $<20°$ and/or an IMA $\leq 11°$) and moderate (HVA 20° to 40° and/or IMA $<16°$) hallux valgus deformity. The patient demographics and preoperative radiologic parameters are listed in Table 1. No significant differences were found between the McBride and chevron groups regarding all these variables.

Surgical Technique

The procedures were performed with the patients in the supine position under spinal anesthesia. For the modified McBride procedure, the adductor hallucis tendon and transverse intermetatarsal ligament were released sharply through a dorsal first web space incision. The lateral capsule of the first metatarsophalangeal joint was perforated using several stab incisions. After a longitudinal medial capsulotomy, the medial eminence of the first metatarsal head was removed in line with the metatarsal shaft. The stump of the adductor hallucis tendon was sutured into the lateral aspect of the first metatarsal neck, and the medial capsule was plicated in slight overcorrection. For the distal chevron osteotomy, the medial eminence was excised, and no lateral soft tissue release was performed. After a 60° V-osteotomy centered on the first metatarsal head, the capital fragment was displaced laterally, and the osteotomy was fixed with a 3.0-mm cannulated screw (Barouk Screw®; DePuy International, Leeds, UK). The medial capsule was imbricated in slight overcorrection.

Postoperatively, each patient wore an open, hard-soled postoperative shoe and was allowed to bear weight as tolerated on the heel and lateral forefoot on the first postoperative day. Use of the postoperative shoe was typically discontinued at 4 weeks in the McBride group and at 4 to 6 weeks in the chevron group after radiographic evidence of healing at the osteotomy site.

Clinical and Radiographic Evaluations

All patients were evaluated clinically before surgery and at the final follow-up visit. The clinical outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) forefoot-metatarsophalangeal-interphalangeal scale (10) and a visual analog scale (VAS) (11) for pain. The patients were also asked whether they were very satisfied, satisfied, unsatisfied, or very unsatisfied with the surgical outcome and whether they would undergo the same procedure again.

Radiographic assessment was performed with weightbearing dorsoplantar and lateral radiographs pre- and postoperatively. On weightbearing dorsoplantar radiographs, 1 independent observer who did not participate in the operative treatment and who was unaware of the purpose of the study measured the HVA, IMA, and the position of the medial sesamoid preoperatively and at the final follow-up visit. The HVA was measured as the angle between the line from the center of the first metatarsal base to the center of the first metatarsal head and the line connecting the midpoints of the proximal and distal articular surfaces of the proximal phalanx (12). The IMA was measured as the angle between the line of the first metatarsal and the line bisecting the diaphyseal portions of the second metatarsal bone (13). The position of the medial sesamoid was categorized into 1 of 7 grades in accordance with the methods of Hardy and Clapham (14). Similar to previous studies (15,16), we defined the recurrence of hallux valgus as an HVA $>15°$, and we assessed hallux valgus recurrence at the final follow-up examination in all patients.

Table 1
Demographics of McBride and chevron groups

Variable	McBride Group (n = 48)	Chevron Group (n = 50)	*p* Value
Age (y)	55.8 ± 11.5	57.9 ± 11.9	.260
Gender			.959
Male	18 (37.5)	19 (38.0)	
Female	30 (62.5)	31 (62.0)	
Follow-up duration (mo)	48.35 ± 23.8	51.3 ± 19.1	.581
Hallux valgus angle (°)	26.5 ± 7.2	27.6 ± 5.9	.379
Intermetatarsal angle (°)	11.7 ± 2.3	11.9 ± 1.9	.771
Sesamoid position (grade)	5.8 ± 0.8	5.9 ± 0.9	.688

Data presented as mean ± standard deviation or n (%).

Statistical Analysis

All statistical analyses were performed with SPSS software for Windows, version 16.01 (SPSS Inc., Chicago, IL). The Student *t* test or Mann-Whitney *U* test were used to compare the continuous variables between groups, and the Wilcoxon signed rank test was used to evaluate the changes between the pre- and postoperative values. The chi-square test or Fisher's exact test was used to compare the nominal variables. The odds ratio for hallux valgus recurrence and 95% confidence interval were calculated using the chi-square test. A p value $< .05$ was considered statistically significant.

Results

The clinical outcomes are summarized in Table 2. The mean AOFAS scores for the McBride and chevron groups improved significantly for both mild ($p = .008$ and $p = .01$, respectively) and moderate ($p < .001$ and $p < .001$, respectively) deformity. The mean preoperative AOFAS score did not differ significantly between the McBride and chevron groups; however, the mean postoperative AOFAS scores and the mean change in the AOFAS scores were significantly greater in the chevron group than in the McBride group for both

Table 2
Clinical outcomes

Variable	McBride Group (n = 48)	Chevron Group (n = 50)	*p* Value
Mild deformity	21 (43.8)	20 (40.0)	
AOFAS scale score			
Preoperatively	58.9 ± 5.4	57.1 ± 3.8	.22
Final follow-up visit	87.2 ± 3.3	91.5 ± 1.6	.004
Difference	28.3 ± 8.0	34.4 ± 2.6	.04
p Value	.008	.01	
VAS score			
Preoperatively	6.9 ± 0.9	7.4 ± 1.5	.43
Final follow-up visit	2.8 ± 0.9	1.2 ± 0.9	.007
Difference	4.3 ± 0.9	6.4 ± 0.8	.002
p Value	.007	.01	
Overall satisfaction			.65
Very satisfied	9 (42.9)	8 (40.0)	
Satisfied	7 (33.3)	6 (30.0)	
Unsatisfied	3 (14.3)	3 (15.0)	
Very unsatisfied	2 (9.5)	3 (15.0)	
Same surgery again			.69
Yes	16 (76.2)	17 (85.0)	
No	5 (23.8)	3 (15.0)	
Moderate deformity	27 (56.2)	30 (60.0)	
AOFAS scale score			
Preoperatively	55.2 ± 6.7	54.9 ± 5.2	.88
Final follow-up visit	84.7 ± 7.3	89.6 ± 3.5	.01
Difference	29.7 ± 8.4	34.7 ± 5.4	.02
p Value	<.001	<.001	
VAS score			
Preoperatively	6.9 ± 1.6	7.2 ± 1.3	.88
Final follow-up visit	3.3 ± 2.3	1.4 ± 1.4	.001
Difference	3.6 ± 3.2	5.7 ± 1.2	.003
p Value	.001	<.001	
Overall satisfaction			.15
Very satisfied	5 (18.5)	13 (43.3)	
Satisfied	12 (44.4)	11 (36.7)	
Unsatisfied	7 (25.9)	3 (10.0)	
Very unsatisfied	3 (11.1)	3 (10.0)	
Same surgery again			.14
Yes	18 (66.7)	25 (83.3)	
No	9 (33.3)	5 (16.7)	

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; VAS, visual analog scale.
Data presented as n (%) or mean ± standard deviation.

mild and moderate deformity. The mean postoperative VAS score was significantly lower in the chevron group than in the McBride group, regardless of the severity of the deformity. The chevron group experienced a significantly greater reduction in the mean VAS score than did the McBride group for both mild (p = .002) and moderate (p = .001) deformity. For mild deformity, 16 patients (76.2%) in the McBride group and 14 (70.7%) in the chevron group were satisfied or very satisfied with the overall outcome of the surgery (p = .65). For moderate deformity, 17 patients (63.0%) in the McBride group and 24 (80.0%) in the chevron group were satisfied or very satisfied (p = .15). The proportion of patients who stated that they would undergo the same procedure again did not differ significantly between the McBride and chevron groups for either mild (p = .69) or moderate (p = .14) deformity.

The radiologic outcomes are summarized in Table 3. For both groups, the mean HVA and IMA had decreased significantly at the final follow-up visit for both mild and moderate deformity. The mean postoperative HVA and IMA were significantly greater in the McBride than in the chevron group for both mild (p = .002 and p = .001, respectively) and moderate (p < .001 and p < .001, respectively) deformity. The chevron group experienced a significantly greater correction in the HVA and IMA than did the McBride group, regardless of the severity of the deformity. The mean grade of sesamoid displacement in both groups was significantly reduced at the final follow-up examination for both mild and moderate deformity. In cases of moderate deformity, the mean postoperative grade of sesamoid displacement was significantly lower in the chevron group than in the McBride group (p = .01), and the chevron group experienced a significantly greater decrease in the grade of sesamoid displacement than did the McBride group (p = .03). These results did not differ between the groups in the cases of mild deformity.

Table 3
Radiographic outcomes

	McBride Group (n = 48)	Chevron Group (n = 50)	*p* Value
Mild deformity (n)	21 (43.8)	20 (40.0)	
Hallux valgus angle (°)			
Preoperatively	18.0 ± 1.4	18.9 ± 0.4	.17
Final follow-up visit	12.7 ± 1.3	9.4 ± 1.7	.002
Correction*	5.3 ± 0.7	9.4 ± 1.8	.001
p Value	.007	.01	
Intermetatarsal angle (°)			
Preoperatively	10.2 ± 0.8	10.3 ± 0.8	.90
Final follow-up visit	8.3 ± 0.9	5.3 ± 1.3	.001
Correction*	1.9 ± 0.6	5.0 ± 1.0	.001
p Value	.006	.01	
Sesamoid position (grade)			
Preoperatively	5.2 ± 0.7	5.4 ± 0.5	.54
Final follow-up visit	4.0 ± 0.5	3.9 ± 0.4	.53
Correction*	1.2 ± 0.4	1.6 ± 0.5	.16
p Value	.005	.01	
Moderate deformity	27 (56.2)	30 (60.0)	
Hallux valgus angle (°)			
Preoperatively	29.8 ± 5.4	29.8 ± 4.1	.77
Final follow-up visit	18.6 ± 3.8	13.0 ± 4.6	<.001
Correction*	11.1 ± 5.4	16.8 ± 4.4	<.001
p Value	<.001	<.001	
Intermetatarsal angle (°)			
Preoperatively	12.1 ± 2.3	12.3 ± 1.9	.85
Final follow-up visit	9.4 ± 2.3	6.3 ± 2.5	<.001
Correction*	2.8 ± 1.5	5.9 ± 2.5	<.001
p Value	<.001	<.001	
Sesamoid position (grade)			
Preoperatively	6.0 ± 0.6	6.0 ± 0.7	.97
Final follow-up visit	4.5 ± 0.6	4.0 ± 1.1	.01
Correction*	1.5 ± 0.5	2.0 ± 0.9	.03
p Value	<.001	<.001	

Data presented as n (%) or mean ± standard deviation.
* Difference between the preoperative and final follow-up values.

In both groups, the recurrence of hallux valgus was observed only in cases of moderate deformity. Hallux valgus recurrence was observed in 21 feet (43.8%) in the McBride group and 6 feet (12.0%) in the chevron group. In moderate deformity, the McBride group had a greater risk of recurrence than did the chevron group (odds ratio 14.00, 95% confidence interval 3.91 to 50.06; p < .001). Ten patients (20.8%; mild deformity in 2 and moderate deformity in 8) in the McBride group and 6 patients (12.0%; mild deformity in 2 and moderate deformity in 4) in the chevron group occasionally complained of pain while standing. Nine patients (18.8%) in the McBride group and 3 patients (6.0%) in the chevron group complained of deformity recurrence. One patient (2.0%) in the chevron group developed transfer metatarsalgia under the second metatarsal head owing to shortening of the first metatarsal.

Discussion

A modified McBride procedure has been recommended for mild to moderate hallux valgus deformity when the HVA is <30° and the IMA is <15° (1). A distal soft tissue procedure should be combined with corrective osteotomy of the first metatarsal if >20° hallux valgus correction is needed (17). A distal chevron osteotomy has been recommended for patients with an HVA of <30° and an IMA of <15° (18,19), and some studies have found that distal chevron osteotomy reliably corrects moderate to severe deformity (20,21). Because these 2 procedures have similar indications, we sought to compare their results in relation to the severity of the deformity. We found that distal chevron osteotomy led to better clinical and radiologic outcomes than the modified McBride procedure.

Some studies have found that a modified McBride procedure results in superior clinical outcomes; however, these studies have also found a high rate of hallux valgus recurrence (range 56% to 72.2%) after this procedure (7,15,16). The definition of hallux valgus recurrence (HVA >15°) used in these studies was the same as that in our study. In contrast, the recurrence rate (HVA >15°) after distal chevron osteotomy has been reported to range from 7.7% to 9.9% (6,21). Consistent with these findings, our results revealed that the recurrence rate was significantly greater in the McBride group than in the chevron group. These studies (7,15,16) on the modified McBride procedure were limited because they did not include a control group; however, 3 previous studies have compared the results of the modified McBride procedure with those of metatarsal osteotomy. Johnson et al (2) compared the results of the distal chevron osteotomy to the modified McBride procedure in patients with mild or moderate hallux valgus deformity; however, they did not analyze the results in terms of the severity of the deformity. They reported that distal chevron osteotomy results in a greater correction of the HVA (p = .025) and IMA (p = .001) than the modified McBride procedure; however, neither procedure improves the medial sesamoid position significantly, and the difference in medial sesamoid position between the 2 procedures was not statistically significant. No statistically significant differences were found between the 2 procedures regarding the clinical outcomes, such as pain relief, cosmetic results, metatarsophalangeal joint mobility, and overall satisfaction. Udin and Dutoit (8) compared the results of the McBride procedure and subcapital osteotomy with an average follow-up period of 19 years. They found that patients were subjectively more satisfied after the McBride procedure (p = .0001) even if the deformity showed greater radiologic improvement with osteotomy (p = .006). Finally, a comparative study by Schwitalle et al (9) found satisfaction rates of 71% after the McBride procedure and 81% after the Mitchell osteotomy. In our study, the mean correction of the HVA and IMA was significantly greater in the chevron group than in the McBride group for both mild and moderate deformity. The postoperative sesamoid position improved significantly in both groups, regardless of the severity of the deformity, although it showed greater improvement in the chevron group than in the McBride group for moderate deformity. During the progression of hallux valgus deformity, the first metatarsal head drifts medially away from the sesamoids, but the sesamoids retain their anatomic relationship to the second metatarsal (17,22). In addition, the sesamoid position appears to correlate significantly with the HVA and IMA (23). This could explain why the mean decrease in the grade of sesamoid displacement in our study was significantly greater in the chevron group than in the McBride group for patients with moderate deformity. The chevron group also achieved greater improvement in the AOFAS scale and VAS scores for both mild and moderate deformity. However, regardless of the severity of the deformity, the 2 groups did not differ significantly in their rates of satisfaction or willingness to undergo the same procedure again, although these 2 clinical parameters were higher in the chevron group. Previous comparative studies (2,8,9) of the McBride procedure and metatarsal osteotomy did not account for the severity of the deformity in the analysis. In contrast, we divided the 2 groups into mild and moderate hallux valgus deformity. In addition, several previous studies, which were not comparative, found that a modified McBride procedure resulted in a high rate of satisfaction and was an efficient approach to eliminate pain (7,15,16). Our results showed that pain relief and patient satisfaction were greater in the chevron group than in the McBride group, although this difference was not statistically significant for patient satisfaction. A modified McBride procedure has been recommended by many investigators for the treatment of mild hallux valgus deformity (7,15,16). However, our results have indicated that the clinical and radiologic outcomes for the chevron group were more favorable than those for the McBride group for both mild and moderate deformity. Our findings also contrast with those from a study by Udin and Dutoit (8) in which the McBride procedure was more effective in alleviating pain than was subcapital osteotomy. They suggested that a lack of correlation between the subjective and radiologic results could be explained because radiographs represent only the static morphologic state of a more complex pathologic entity. Thus, radiologic examination can only partly explain the functional discomfort of patients. Therefore, further study is needed to explain the relationship between subjective and radiologic results after hallux valgus surgery.

The present study was limited by its retrospective design. The other limitation of our study was that our senior author (T.S.K.) performed the modified McBride procedures in the first half of the study and distal chevron osteotomies in the second half. Therefore, increasing surgeon experience could have influenced the results. However, the surgeon had had much experience in hallux valgus surgery at the start of the study, and these 2 procedures differ technically from each other. Thus, much evolution of the surgical technique did not seem to occur.

In conclusion, the clinical and radiologic outcomes of the present study have indicated that the distal chevron osteotomy is superior to the modified McBride procedure for the treatment of mild and moderate hallux valgus deformity. The McBride procedure was associated with a greater risk of hallux valgus recurrence than was the distal chevron osteotomy in patients with moderate deformity. Therefore, we recommend distal chevron osteotomy rather than a modified McBride procedure for the treatment of mild to moderate hallux valgus.

References

1. Coughlin MJ. Hallux valgus. J Bone Joint Surg Am 78:932–966, 1996.
2. Johnson JE, Clanton TO, Baxter DE, Gottlieb MS. Comparison of chevron osteotomy and modified McBride bunionectomy for correction of mild to moderate hallux valgus deformity. Foot Ankle 12:61–68, 1991.
3. Meyer JM, Hoffmeyer P, Borst F. The treatment of hallux valgus in runners using a modified McBride procedure. Int Orthop 11:197–200, 1987.
4. Jones S, Al Hussainy HA, Ali F, Betts RP, Flowers MJ. Scarf osteotomy for hallux valgus. A prospective clinical and pedobarographic study. J Bone Joint Surg Br 86:830–836, 2004.
5. Trnka HJ, Parks BG, Ivanic G, Chu IT, Easley ME, Schon LC, Myerson MS. Six first metatarsal shaft osteotomies: mechanical and immobilization comparisons. Clin Orthop Relat Res 381:256–265, 2000.
6. Lee HJ, Chung JW, Chu IT, Kim YC. Comparison of distal chevron osteotomy with and without lateral soft tissue release for the treatment of hallux valgus. Foot Ankle Int 31:291–295, 2010.
7. Kayali C, Ozturk H, Agus H, Altay T, Hancerli O. The effectiveness of distal soft tissue procedures in hallux valgus. J Orthop Traumatol 9:117–121, 2008.
8. Udin B, Dutoit M. Hallux valgus: the McBride procedure or subcapital osteotomy?. Rev Chir Orthop Reparatrice Appar Mot 78:169–175, 1992.
9. Schwitalle M, Karbowski A, Eckardt A. Hallux valgus in young patients: comparison of soft-tissue realignment and metatarsal osteotomy. Eur J Pediatr Surg 8:42–46, 1998.
10. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 15:349–353, 1994.
11. Wewers ME, Lowe NK. A critical review of visual analogue scales in the measurement of clinical phenomena. Res Nurs Health 13:227–236, 1990.
12. Smith RW, Reynolds JC, Stewart MJ. Hallux valgus assessment: report of research committee of American Orthopaedic Foot and Ankle Society. Foot Ankle 5:92–103, 1984.
13. Schneider W, Csepan R, Knahr K. Reproducibility of the radiographic metatarsophalangeal angle in hallux surgery. J Bone Joint Surg Am 85-A:494–499, 2003.
14. Hardy RH, Clapham JC. Observations on hallux valgus: based on a controlled series. J Bone Joint Surg Br 33-B:376–391, 1951.
15. Mann RA, Pfeffinger L. Hallux valgus repair: DuVries modified McBride procedure. Clin Orthop Relat Res 272:213–218, 1991.
16. Yucel I, Tenekecioglu Y, Ogut T, Kesmezacar H. Treatment of hallux valgus by modified McBride procedure: a 6-year follow-up. J Orthop Traumatol 11:89–97, 2010.
17. Mann RA, Coughlin MJ. Hallux valgus—etiology, anatomy, treatment and surgical considerations. Clin Orthop Relat Res 157:31–41, 1981.
18. Schneider W, Aigner N, Pinggera O, Knahr K. Chevron osteotomy in hallux valgus: ten-year results of 112 cases. J Bone Joint Surg Br 86:1016–1020, 2004.
19. Trnka HJ, Zembsch A, Easley ME, Salzer M, Ritschl P, Myerson MS. The chevron osteotomy for correction of hallux valgus: comparison of findings after two and five years of follow-up. J Bone Joint Surg Am 82-A:1373–1378, 2000.
20. Bai LB, Lee KB, Seo CY, Song EK, Yoon TR. Distal chevron osteotomy with distal soft tissue procedure for moderate to severe hallux valgus deformity. Foot Ankle Int 31:683–688, 2010.
21. Murawski DE, Beskin JL. Increased displacement maximizes the utility of the distal chevron osteotomy for hallux valgus deformity correction. Foot Ankle Int 29:155–163, 2008.
22. Talbot KD, Saltzman CL. Assessing sesamoid subluxation: how good is the AP radiograph? Foot Ankle Int 19:547–554, 1998.
23. Agrawal Y, Desai A, Mehta J. Lateral sesamoid position in hallux valgus: correlation with the conventional radiological assessment. Foot Ankle Surg 17:308–311, 2011.

Decision Making in the Treatment of Hallux Valgus

Thomas N. Joseph, M.D., and Kenneth J. Mroczek, M.D.

Hallux valgus (HV) is a valgus angulation of the first metatarsophalangeal (MTP) joint of the great toe. Hallux valgus is distinct from a bunion, which is an exostosis on the dorsomedial aspect of the first metatarsal (MT) head. The word bunion is derived from the Greek, *bunio,* and means turnip; better known is the meaning of the Latin derived *hallux valgus*, that roughly translates to "large toe with an outward angulation," but more informally as a "crooked big toe." Hallux valgus is also frequently painful and may both limit physical activities and create a psychological distress for patients, depending on the severity of the deformity. The condition of HV includes not only the outward lateral deviation of the great toe (distal segment of the first metatarsal) but a medial deviation of the first MT. Commonly, there is progressive subluxation of the first MTP joint. Occasionally, there is a static deformity due to valgus angulation of the distal articular surface of the first MT or proximal phalangeal articular surface.

Constricting footwear is a major extrinsic cause of HV. Couglin and Thompson noted the high prevalence of HV in American females in the fourth, fifth, and sixth decades of life and its probable association with footwear type.[1] The prevalence of HV in Japanese females also increased dramatically after the introduction of high-fashion footwear following WWII."[2]

Intrinsic factors also play a role in HV; those suggested include: pronation of the hind foot, pes planus, an increased angle between the first and second MT (metatarsus primus varus), association between the HV angle and the first to second intermetatarsal angle, contracture of the Achilles tendon, generalized joint laxity, and hypermobility of the first MT-cuneiform joint. Heredity also can be a factor in HV. Hardy and Clapham[3] showed that 63% of patients with HV had a parent with HV. Coughlin[4] reported a 94% incidence of bunions in mothers of children with HV. Finally, neuromuscular disorders, including cerebral palsy and stroke, can play a role.

Thomas N. Joseph, M.D., was Chief Resident in the NYU Hospital for Joint Diseases Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York, New York. Kenneth J. Mroczek, M.D., is Assistant Professor of Orthopaedic Surgery, NYU School of Medicine, New York, New York and Chief of the Foot and Ankle Service, NYU Hospital for Joint Diseases Department of Orthopaedic Surgery, New York, New York.
Correspondence: Kenneth J. Mroczek, M.D., Suite 5D, New York University Medical Center, 530 First Avenue, New York, New York 10016.

Anatomy*

The MTP first ray is unique. It possesses a sesamoid mechanism and a set of intrinsic musculature that provide stability and strength. As described by Coughlin, The muscles and tendons can be separated into four groups that surround the first MTP. Dorsally, the extensor hallucis longus (EHL) inserts onto the distal phalanges and the extensor hallucis brevis (EHB) onto the proximal phalanges. The EHL is secured by the hood ligaments, fashioning the capsule of the MTP joint. The flexor hallucis longus (FHL) and flexor hallucis brevis (FHB) are present on the plantar aspect of the foot. The tendons of the medial and lateral heads of the FHB insert onto the medial and lateral sesamoids, respectively. The sesamoid bones are fastened to the base of the proximal phalanx via the plantar plate. The FHL, which inserts onto the base of the distal phalanx, is plantar to the sesamoid complex, and encased within its own tendon sheath.

The abductor (AbH) and adductor (AdH) hallucis tendons are located plantar medial and plantar lateral, respectively; they insert into base of the proximal phalanx and the sesa-

*The reader is referred to the comprehensive article "Hallux Valgus" by Michael J. Coughlin, from which parts of the anatomical description were used: Instr Course Lect. 1997;46:357-91 or J Bone Joint Surg Am. 1996;78(6):932-66.

moids. The plantar half of the MTP joint capsule is reinforced by the tendons of the AbH and AdH. The dorsal half is thin and without tendinous constraints. As HV increases, the AdH becomes a deforming force and tethers the sesamoids and proximal phalanx as the first MT deviates medially. The tendon exerts a rotational force, because it inserts on the plantar aspect of the proximal phalanx. The plantar cuff (AbH, FHB, and AdH) rotates laterally; the EHL then displaces into the first interspace and becomes an adduction force. This results in lateral subluxation of the sesamoids. The crista, or intersesamoid ridge, articulates with the medial and lateral sesamoids. As displacement occurs, this ridge is smoothed out until it offers no resistance to displacement.

History and Physical Examination

The occupational history of the patient is very important and one should inquire whether their job requires them to be on their feet all day, working at heights**,** or wearing stylish shoes with a narrow toe box. If a patient has an occupation that requires standing, financial difficulties could result. Information should be acquired as well about the frequency of recreational activities such as running, jumping, racquet sports, gymnastics, and basketball. Athletes should be counseled that they might not be able to return to their previous level of play.

With respect to shoe wear, relief of pain is the major objective. Improved appearance and ability to wear smaller or narrower shoes frequently are goals of the patient but may not be verbalized. Mann and associates[5] found that 41% of patients were unable to wear their choice of shoe following HV repair. Postoperative expectations should be addressed preoperatively, whether a patient desires cosmesis or pain relief.

The physical examination must be thorough. The medial eminence (bunion) is often the most visible feature on physical examination. Pain over the medial eminence is often the primary symptom, due to irritation of the dorsal or plantar cutaneous nerve of the great toe, an inflamed or thickened bursa, or skin irritation or breakdown; only occasionally is the bone truly hypertrophied.

Physical examination should be performed with the patient both sitting and standing. During weightbearing, the deformity is generally accentuated. The examiner should evaluate the patient for assessment of pes planus and contracture of the Achilles tendon. The longitudinal arch and great toe, with its relation to the lesser toes, are also examined.

Careful measurement is made regarding the magnitude of the HV, the pronation of the great toe, gait abnormalities, motor weakness, or abnormal alignment of the lower extremity. Passive and active range of motion (ROM) of the MTP joint should be performed. Pain and crepitus can indicate degenerative joint disease (DJD). The physician should attempt to manually correct the hallux valgus deformity, moving the great toe in dorsiflexion and plantar flexion. This maneuver will demonstrate the approximate amount of surgical correction that can be performed while maintaining a satisfactory range of motion. To evaluate for metatarsocuneiform (MTC) hypermobility, the examiner must hold the second MT head in one hand and the first MT in the other. The first MT head subsequently is deviated dorsomedially and then plantar laterally. Greater than 9 mm of deviation represents hypermobility.[6] Significant instability is observed in about 5% of patients with HV.[7] This condition is often associated with moderate to severe flatfoot deformity. Next, the lesser toes are inspected. The lesser toes can cause significant pain, even though their deformity is secondary to HV. Conditions such as hammertoe of the second toe, metatarsalgia of the lesser MTP joints, plantar surface keratoses, and callosities can be present. Doppler studies should be obtained if there is any question of adequate circulation.

Radiological Assessment

Radiographic examination should include weightbearing anterior-posterior (AP), lateral, and axial (sesamoid) radiographs, routinely. Radiographic measurements are made using standing radiographs. The HV angle is the intersection of the longitudinal axes of the proximal phalanx and the first MT. A normal HV angle is considered to be less than 15°. The 1-2 intermetatarsal angle is the intersection of the longitudinal axes of the first and second metatarsals. Less than 9° is considered normal. Subluxation of the lateral sesamoid, as measured on the AP radiograph, can be used for classification.

Broadly, mild HV is defined as an HV angle of less than 20° and a 1-2 intermetatarsal (IM) angle less than 11°, with less than 50% subluxation of the lateral sesamoid. Moderate HV is a HV angle of 20° to 40° and a 1-2 IM angle that is less than 16°, with 50% to 75% subluxation of the lateral sesamoid. Severe HV is defined as a HV angle greater than 40°, a 1-2 IM angle that is greater than 16°, and more than 75% subluxation of the lateral sesamoid.

The radiographic morphology of the distal articular surface of the first MT can vary. A rounded contour is the most common and more prone to subluxation. A flattened or chevron-shaped contour is more stable. Congruity, or correspondence in character, is ascribed to the normal relationship between the MT and phalangeal surfaces. The relation is considered “congruous” when the joint surfaces are parallel, and there is no lateral subluxation; the surfaces are “aligned.” The relation is described as noncongruous when the joint surfaces are not aligned, there is subluxation of MTP joint, and the joint surfaces are no longer parallel. Lateral subluxation of the proximal phalanx occurs on the MT head. A congruous joint is less likely to have a progression of HV. A noncongruous joint is more likely to subluxate further with time.

The distal metatarsal articular angle (DMAA) describes the relationship between the distal articular surface and the long axis of the first MT. A normal angle is less than 10°. The DMAA is also known as MT articular orientation or proximal articular set angle (PASA). The proximal articular surface of the proximal phalanx forms an angle with the longitudinal axis of the proximal phalanx, the proximal phalangeal articular angle (PPAA). This angle is also called the phalangeal articular orientation or the distal articular set angle (DASA).

Hallux valgus interphalangeus is the angle between the lines bisecting the proximal and distal phalanges of the metatarsal. A normal angle is less than 10°. With progressive MTP subluxation, a groove (sagittal sulcus) develops at the medial border of the MT articular surface. The magnitude of the HV deformity determines the presence and location of the angle. While it delineates the border of the articular surface, it is an unreliable landmark for the planning of a medial exostectomy. In severe deformities, the hallux valgus interphalangeus angle may be located in the center of the MT head. Its use as a guide may lead to excessive bone resection.

The shape and orientation of the MTC is variable and influences the magnitude of medial inclination of the first MT. Normally, the first MTC is inclined medially. Occasionally, there is increased medial obliquity that may result in instability of the MTC joint. The first MTC may appear flat, curved, or oblique and may vary with the plane of the radiograph.

Treatment

Nonoperative

The first treatment option is nonoperative care. Adjustment to footwear can be utilized to eliminate friction over the medial eminence, e.g., providing a wider and deeper toe box. The condition of pes planus may be helped by an orthosis. If the pes planus condition is severe, this can lead to a recurrence of HV. Achilles contracture may require stretching or even lengthening.

Operative

Only after nonoperative treatment fails should surgery be considered. Surgical options include proximal phalangeal osteotomy, MTP soft tissue reconstruction, distal or proximal MT osteotomy, MTC arthrodesis, MTP arthrodesis, or excisional arthroplasty.

The Akin procedure is a medial eminence resection, medial capsular reefing, and a medial closing-wedge phalangeal osteotomy. An increased 1-2 intermetatarsal angle is not corrected by this technique. Indications for the procedure include HV interphalangeus, mild HV without MT primus varus, and a mild HV with an enlarged medial eminence. In a congruous MTP joint with HV, an Akin procedure can be combined with an MT osteotomy for extra-articular realignment. Goldberg and colleagues,[8] in 351 patients, showed a 53% satisfaction rate; however, there also was a 21% recurrence rate. Broad indications were applied: HV angle less than 40° and no osteoarthritic (OA) changes. Frey and colleagues[9] demonstrated, in 45 feet, 89% good to excellent results. Most surgeries were performed for second toe symptoms. The outcome of the series included one nonunion and one recurrence. Plattner and Van Manen,[10] in 22 patients, had an average correction of the HV angle of 13°. At 4.5 years, there was a 6° correction, with a 61.5% satisfaction rate reported. The investigators suggested that a major indication for the Akin procedure is HV interphalangeus and that the procedure is not indicated for HV with subluxation of the MTP joint.

Distal Soft Tissue Realignment

The Silver procedure is a medial capsulorrhaphy, medial exostectomy, lateral capsular release, and adductor release. The McBride modification describes the removal of the lateral sesamoid and transfer of the adductor to the lateral aspect of the MT head. This procedure was modified further to exclude sesamoid excision due to the high rate of hallux varus. Indications include a noncongruous HV deformity of less than 30° and a 1-2 intermetatarsal angle of less than 15°. The foot must have mobility of the first MTC joint so that the 1-2 intermetatarsal angle can decrease.

Kitaoka and colleagues,[11] performed a simple bunionectomy and medial capsulorrhaphy, with or without lateral capsulotomy, in 49 feet. They found 67% good to excellent results, with a 29% reoperation at five years. The procedure was most successful for patients who presented with and had treatment for a painful medial eminence. Mann and Pfeffinger,[12] in 72 feet, found a 92% satisfaction rate. The HV angle improved from 32° to 16° and the IM angle from 14° to 9°. There was no postoperative progression of the HV deformity at an average of 4 years; 64% wore unrestricted footwear. The investigators found the procedure was not appropriate for a severe deformity. Six patients had hallux varus (average 7.5°). They recommended the procedure for a HV angle of less than 30° and an intermetatarsal angle less than 15°.

The Chevron osteotomy is a medial eminence resection, distal MT osteotomy, and medial capsulorrhaphy. Indications include a HV angle less than 30°, a 1-2 IM angle less than 13°, subluxation of the MTP joint, and a congruous MTP joint if the DMAA is less than 15°. Chevron osteotomy does not correct pronation and only partially corrects the sesamoids. A phalangeal osteotomy can be added to improve alignment. A lateral soft-tissue release is discouraged, as it may result in devascularization of the MT head. Results by Hattrup and Johnson,[13] in 225 feet, showed complete satisfaction in 79.1%, satisfaction but with reservations in 12.9%, and dissatisfaction in 8%. The average correction of the HV angle was 12° to 13° and the IM angle was 4° to 5°. Meier and Kenzora[14] examined 72 feet. They found a 74% satisfaction if the IM angle was more than 12° and a 94% satisfaction rate if the IM angle was 12° or less. Stienstra and colleagues,[15] in 38 feet, found that the HV angle corrected an average of 18° and the IM angle 11°; 95% had no activity limitations. The most frequent complications associated with the Chevron osteotomy are recurrence (especially with large corrections), loss of correction due to slippage at the osteotomy, transfer metatarsalgia, and osteonecrosis. Osteonecrosis can be increased after performing an adductor tenotomy.

Mitchell and Wilson, among several others,[16] described a distal MT osteotomy in a biplanar or oblique fashion, respectively. Indications include a HV angle of less than 35°, an IM angle of less than 15°, subluxation of the MTP joint, and a congruous MTP joint if the DMAA is less than 15°. The average correction of the HV angle is 10° to 25° and the IM angle 5° to 10°. Excessive shortening with transfer metatarsalgia and callus formation occurs in 20% to 40%. Under correction, recurrence, and osteonecrosis (increased with adductor release) can occur.

A proximal MT osteotomy with distal soft tissue reconstruction can be performed in several ways. These include an opening-wedge, closing-wedge, oblique (a.k.a. Ludloff), Chevron, crescentic, or Scarf (Z-shaped). Indications include moderate to severe HV with a HV angle of 35° or greater and an IM angle 13° or greater, with subluxation of the MTP joint. Average correction of the HV angle is 24°. The IM angle corrects 8° to 11° with a crescentic, 3° to 6° with a closing-wedge, and 7° with an opening-wedge osteotomy. A crescentic osteotomy causes minimal shortening. Complications include recurrence, under correction, and overcorrection, failure of fixation, shortening, metatarsalgia, and delayed union or malunion. Mann and workers[5] examined 109 feet and found a 93% satisfaction rate. The HV angle corrected from 31° to 9° and the IM angle from 14° to 6°. However, they discovered hallux varus in 13 feet. Thordarson and Leventen[17] examined the results of 33 feet in 23 patients. They found an HV angle correction from 37.5° to 13.8° and an IM angle correction of 14.9° to 4.7°. Hallux varus occurred in four feet. They concluded that the use of screws or screws and K-wires increased stability with less shortening.

The modified Lapidus procedure is an arthrodesis of the first MTC joint with distal soft tissue realignment of the MTP joint. Indications include a moderate to severe HV with a HV angle 30°+ and an IM angle 16°+, with MTP subluxation and MTC hypermobility or generalized ligamentous laxity. The procedure is also indicated in recurrent deformity in adolescents or young adults. Average correction of the HV angle is 18° and the IM angle is 6° to 8°. There is, however, a lengthy convalescence (cast until radiographic healing is observed). Complications include nonunion (10% to 12%), malunion (up to 20%), plantar keratosis if excessive plantar flexion, lateral metatarsalgia if excess dorsiflexion, under correction, and overcorrection with occurrence of hallux varus. Mauldin and colleagues,[18] in 51 feet, found 90% patient satisfaction. The procedure incorporated the use of inlay bone block. The results included a 25.5% achievement of bony union at 27.6 months and 8 occurrences of hallux varus. Myerson and workers[19] examined 67 feet and found 77% attained complete relief and 15% partial relief. They found a correction of the HV angle of 34.5° to 14° and that of the IM angle of 14.3° to 5.8°. There were seven nonunions (one symptomatic), three dorsal bunions (one repeat surgery), one hallux varus, and three neuromas of the deep peroneal nerve.

Arthrodesis of the first MTP joint is considered a salvage procedure for severe HV, recurrent HV, rheumatoid arthritis, previous infection, posttraumatic OA, or HV associated with a neuromuscular disorder. The osteotomy can be performed as a flat osteotomy or cup-shaped, using specially made reamers. Fixation can be with compression screws, Steinmann pins, Kirschner wires, staples, or compression plates. Acceptable alignment is 15° to 20° valgus, 20° to 30° dorsiflexion, and neutral rotation. Overall successful fusion with dorsal plating is 92% to 100%. Alignment and fixation are critical for success. Too little valgus angle causes increased interphalangeal OA. Excess plantar flexion causes increased pressure beneath the tip of the toe. Excess dorsiflexion causes plantar keratoses beneath the sesamoids. Coughlin and Abdo used a Vitallium plate in 58 feet due to its low profile.[20] Virtually all (98%) cases fused with 93% good or excellent results. Plate removal was required in four feet. Nonunion and delayed union occurred in one foot each.

Excisional arthroplasty (a.k.a. Keller) is a medial eminence resection, partial proximal phalangectomy, and medial capsular plication. Indications include moderate HV with a HV angle less than 30° and limited ambulatory expectations in older, sedentary patients with OA of the MTP joint. The surgery is considered a salvage procedure. Results show the HV angle reduced 50% with no significant change in IM angle. Functional results deteriorate with time. Transfer metatarsalgia can occur since the first toe is unable to bear weight. Also, a cock-up deformity, stiffness of the IP joint, shortening, impaired control and function, and decreased flexor strength are known complications of this procedure.

Other surgical treatments include multiple osteotomies (double or triple osteotomies). Nine percent of adults with HV have congruous MTP joints, potentiating the need for such a procedure. The indication for a multiple osteotomy procedure is a large DMAA (greater than 15°) with a congruous MTP joint. Complications include loss of fixation, loss of correction, malunion, osteonecrosis, intraarticular extension of the osteotomy, and degenerative OA of the IP or MTP joint. Coughlin and Carlson[21] treated 21 feet. The patients' average age was 26 years. They found a correction of the HV angle to 23° and the IM angle to 9°. One hallux varus and one malunion occurred (both required surgery).

Summary

The surgeon must determine the pathologic elements that need correction. Close observation for an increased HV angle, increased IM angle, pronation of the first toe, increased DMAA, enlarged medial eminence, and subluxation of the sesamoids must be performed. While there are a large number of procedures available for the management of HV, no one method sufficiently corrects all HV deformities. The upper limits of deformity correction for each procedure vary with the surgeon and their familiarity with each procedure. Ultimately, the surgeon must attempt to maintain a flexible first MTP joint and preserve the normal weightbearing pattern of the forefoot. Patient education also can be assistive in avoiding aggravating activities and making better choices in shoe wear. Tracings of the weightbearing foot and the shoe can be used to demonstrate to patients the size differences between the natural size and shape of the foot and that of the shoe, both pre- and postoperatively.

References

1. Coughlin MJ, Thompson FM. The high price of high-fashion footwear. Instr Course Lect. 1995;44:371-7.
2. Kato T, Watanabe S. The etiology of hallux valgus in Japan. Clin Orthop Relat Res. 1981;(157):78-81.
3. Hardy RH, Clapham J. Observations on hallux valgus based on a controlled series. J Bone Joint Surg Br. 1951;33:376-91.
4. Coughlin MJ. Roger A Mann Award. Juvenile hallux valgus: Etiology and treatment. Foot Ankle Int. 1995;16(11):682-97.
5. Mann RA, Rudicel S, Graves SC. Repair of hallux valgus with a distal soft-tissue procedure and proximal metatarsal osteotomy. A long-term follow-up. J Bone Joint Surg Am. 1992;74(1):124-9.
6 Klaue K, Hansen ST, Masquelet AC. Clinical, quantitative assessment of first tarsometatarsal mobility in the sagittal plane and its relation to hallux valgus deformity. Foot Ankle Int. 1994;15(1):9-13.
7. Mann RA, Coughlin MJ. *Surgery of the Foot and Ankle*. (6th ed). St. Louis: Mosby, 1993.
8. Goldberg I, Bahar A, Yosipovitch Z. Late results after correction of hallux valgus deformity by basilar phalangeal osteotomy. J Bone Joint Surg Am. 1987;69:64-7.
9. Frey C, Jahss M, Kummer FJ. The Akin procedure: An analysis of results. Foot Ankle 1991;12(1):1-6.
10. Plattner PF, Van Manen JW. Results of Akin type proximal phalangeal osteotomy for correction of hallux valgus deformity. Orthopedics. 1990;13(9):989-96.
11. Kitaoka HB, Franco MG, Weaver AL, et al. Simple bunionectomy with medial capsulorrhaphy. Foot Ankle. 1991;12(2):86-91.
12. Mann RA, Pfeffinger L. Hallux valgus repair. DuVries modified McBride procedure. Clin Orthop Relat Res. 1991;(272):213-18.
13. Hattrup SJ, Johnson KA. Chevron osteotomy. Analysis of factors in patients' dissatisfaction. Foot Ankle. 1985;5(6):327-32.
14. Meier PJ, Kenzora JE. The risks and benefits of distal first metatarsal osteotomies. Foot Ankle. 1985;6(1):7-17.
15. Stienstra JJ, Lee JA, Nakadate DT. Large displacement distal chevron osteotomy for the correction of hallux valgus deformity. J Foot Ankle Surg. 2002;41(4):213-20.
16. Robinson AH, Limbers JP. Modern concepts in the treatment of hallux valgus. J Bone Joint Surg Br. 2005;87:1038-46.
17. Thordarson DB, Leventen EO. Hallux valgus correction with proximal metatarsal osteotomy: Two-year follow-up. Foot Ankle. 1992;13(6):321-26.
18. Mauldin DM, Sanders M, Whitmer WW. Correction of hallux valgus with metatarsocuneiform stabilization. Foot Ankle. 1990;11(2):59-66.
19. Myerson M, Allon S, McGarvey W. Metatarsocuneiform arthrodesis for management of hallux valgus and metatarsus primus varus. Foot Ankle. 1992;13(3):107-15.
20. Coughlin MJ, Abdo RV. Arthrodesis of the first metatarsophalangeal joint with Vitallium plate fixation. Foot Ankle Int. 1994;15(1):18-28.
21. Coughlin MJ, Carlson RE. Treatment of hallux valgus with an increased distal metatarsal articular angle: Evaluation of double and triple first ray osteotomies. Foot Ankle Int. 1999;20(12):762-70.

AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International
34(5) 684–690

DOI: 10.1177/1071100712472489
fai.sagepub.com

Prospective Study of the Treatment of Adult Primary Hallux Valgus With Scarf Osteotomy and Soft Tissue Realignment

Jae Hyuck Choi, MD[1], Jacob R. Zide, MD[1], Scott C. Coleman, MS, MBA[1], and James W. Brodsky, MD[1]

Abstract

Background: The scarf osteotomy has been a widely practiced bunion operation, but relatively limited prospective data on its outcomes have been reported. The purpose of this investigation was to prospectively evaluate the clinical and radiographic results of treatment of adult primary hallux valgus using the scarf osteotomy of the first metatarsal with soft tissue realignment.

Methods: Hallux valgus corrections were performed on 51 patients (53 feet), who were followed for at least 1 year with an average follow-up of 24 months. Mean age at the time of surgery was 59 years, and subjects included 3 male and 48 female patients. Prospective clinical data collected included the American Orthopaedic Foot & Ankle Society (AOFAS) hallux-interphalangeal scale score, the SF-36 scores, and the visual analogue scale (VAS) for pain. Data were collected preoperatively and postoperatively. Prospective radiologic data were also collected including hallux valgus angle (HVA), first-second intermetatarsal angle (IMA), and medial sesamoid position (MSP). Clinical data were collected on complications and reoperations.

Results: Mean AOFAS hallux-interphalangeal score increased from 52 preoperatively to 88 postoperatively. Mean preoperative and last follow-up SF-36 physical component summary increased from 46 preoperatively to 52 postoperatively, whereas mean VAS pain scores decreased from 5.8 preoperatively to 1.1 postoperatively. All the changes in clinical outcomes were statistically significant, except the Mental Component Summary of the SF-36. Mean preoperative HVA decreased from 29 degrees preoperatively to 10.7 degrees in the initial postoperative period and was maintained at last follow-up at 10.6 degrees. The mean preoperative IMA decreased from 13.6 degrees preoperatively to 5.6 degrees in the initial postoperative period and regressed mildly at last follow-up to 7.8 degrees. The mean preoperative MSP grade of 2.3 decreased to 0.5 in the initial postoperative period and regressed mildly to 0.9 at last follow-up. All radiographic changes were statistically significant. The overall complication rate was 15% (8/53), attributable to 4 feet with symptomatic hardware, 2 feet with hallux varus, and 2 feet with progression of first MTP arthritis. Reoperations were performed in 4 feet (8%) for removal of symptomatic hardware.

Conclusion: Scarf osteotomy was a reliable technique for correction of moderate to severe hallux valgus and had low rates of complication or recurrence.

Level of Evidence: Level IV, case series.

Keywords: hallux valgus, scarf, bunion, osteotomy, soft tissue realignment

Although correction of hallux valgus deformity with scarf osteotomy has been especially popular in other countries, it has been slower to gain favor among orthopedic surgeons in the United States. This may be attributable, in part, to the early reports in the American literature of associated pitfalls and complications.[4,5] Although hallux valgus can be treated with many techniques, numerous retrospective and a limited number of prospective studies have reported good results following use of the scarf osteotomy.[2,6,9,13,16,21,24,30,31] Although most studies have reported positive results, a few have reported negative results.[4,5]

This prospective study was undertaken to prospectively evaluate the clinical and radiographic outcomes of scarf osteotomy in the treatment of adult idiopathic, primary hallux valgus. Secondarily, we sought to investigate not only the corrective power of the scarf osteotomy but the intermediate

[1]Baylor University Medical Center, Dallas, Texas, USA

Corresponding Author:
James W. Brodsky, MD, Baylor University Medical Center, 411 N. Washington Avenue, Ste, 2100, Dallas, TX 75246, USA
Email: jbrodsky@dallasortho.com

Table 1. Demographic Data

Patients/feet	51/53
Sex	Female 50, male 3
Age in years (range)	59 (32-80)
Left: right	25:28
Follow-up mean in months (range)	24 (12-66)

durability and maintenance of correction using this procedure, which has seldom been reported after operative reconstruction of hallux valgus.

Methods

All recruited subjects gave informed consent to participate in this study, according to institutional review board guidelines in our institution. Prospective data were collected for all patients who underwent a scarf osteotomy with soft tissue realignment by the senior author (J.B.) for treatment of adult primary, idiopathic hallux valgus over a 2-year period. All patients with moderate to severe hallux valgus were treated with this technique during the study period. Among 63 patients (66 feet) operated in the study period, 13 cases were excluded: 6 feet in 5 patients who had rheumatoid arthritis; 1 each who had psoriatic arthritis and systemic lupus erythematosus; 1 patient with juvenile hallux valgus; and 2 cases that were revisions of prior failed hallux valgus corrections. Two patients were lost to follow-up. The diagnosis for the remaining 53 feet in 51 patients was symptomatic, adult idiopathic hallux valgus.

Mean age at the time of surgery was 59 years (range, 32-80 years), including 48 female and 3 male patients. There were 28 right feet and 25 left feet. Each patient had a minimum follow-up of 12 months, and mean follow-up from surgery was 24 months (range, 12-66 months) (Table 1).

Multiple data were collected preoperatively and again at the final follow-up. These included the American Orthopaedic Foot & Ankle Society (AOFAS) hallux-interphalangeal scale,[27] the SF-36 questionnaire, and the visual analogue scale (VAS) for pain. Patient charts were reviewed for complications, reoperation, and concomitant operative procedures. Weight-bearing anteroposterior radiographs were evaluated and measured preoperatively and in the early postoperative period, once the patient could bear weight for standing radiographs (within 6 weeks), and then again at most recent follow-up. Radiographic technique was standardized and done weight-bearing according to the same protocol and by the same radiographers preoperatively and postoperatively.

Radiographic measurements included the hallux valgus angle (HVA), which was assessed using the intersection of the bisection of the first metatarsal and proximal phalanx using the technique described by Miller[18]; the first-second intermetatarsal angle (IMA), which was measured by the intersection of the bisection of the first metatarsal and second metatarsals; and the medial sesamoid position (MSP), which was graded on a scale of 0 to 3 in relation to the bisection of the first metatarsal according to the technique of Smith et al.[27] Concomitant procedures included hammertoe corrections in 29 patients, Akin osteotomies in 23 patients, Weil osteotomies of the second metatarsal in 3 patients, bunionette excision in 3 patients, and neuroma excision in 2 patients.

Statistical Analysis

Preoperative and postoperative values for clinical outcome scores and for radiographic measurements were compared using the paired Student t test, with the exception of the MSP, which was compared using the Wilcoxon paired t test. Statistical significance was assigned to *P* values of less than .05.

Operative Technique

There was a marked variation of operative techniques used among previous reports (or an absence of a description of the technique used), signifying that all operative procedures called the "scarf osteotomy" may not have been the same. The operative technique used in this series is described in detail here. All surgeries were performed using a field block according to a published techinque.[23] An Esmarch tourniquet was applied above the malleoli. An open lateral release was performed through a 3-cm dorsal incision in the first intermetatarsal web, releasing the attachment of the adductor hallucis tendon from the lateral sesamoid, and a horizontal capsulotomy was performed between the plantar surface of the lateral condyle of the first metatarsal and the sesamoid sling. The lateral capsule was not vertically or otherwise incised or perforated.

A medial longitudinal incision was made over the medial aspect of the first metatarsophalangeal joint (MTP) and first metatarsal. After the surgeon elevated dorsal and plantar flaps at the joint, including the periosteum, for the soft tissue realignment, the osteotomy was performed with a straight blade on an electric microsaw. Resection of the medial eminence of the first metatarsal head either was not done or was very minimal in order to preserve the articular surface and reduce the risk of hallux varus. Such resection, if performed, was done after fixation of the osteotomy. The osteotomy was performed as depicted in Figure 1. The key point is the extension of the osteotomy into the distal and proximal metaphyses of the first metatarsal to prevent "troughing," that is, collapse of the dorsal segment into the plantar one. Unlike other proximal osteotomies, or tarsometatarsal arthrodesis, the scarf osteotomy was displaced

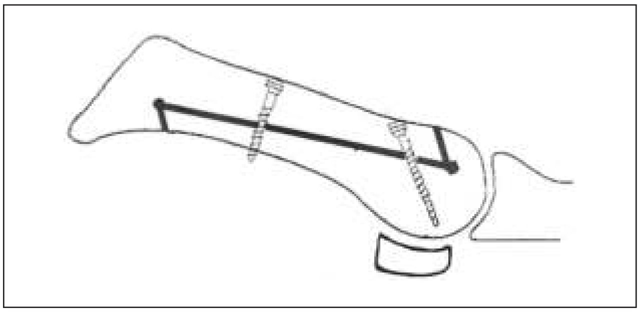


Figure 1. Configuration of scarf osteotomy: medial view. Drawing represents key features of the scarf osteotomy as used in this series: a longitudinal osteotomy extending into proximal and distal metaphyseal zones of first metatarsal, with parallel, slightly oblique transverse limbs at proximal and distal extents. Transverse limbs are angled proximally, from medial to lateral, creating an element of shortening. The point of intersection of the longitudinal and transverse cuts is more dorsal distally (one-third the distance from dorsal to plantar) and more plantar at proximally (two-thirds the distance from dorsal to plantar).

primarily by lateral translation rather than valgus rotation in order to correct the first metatarsal varus. The displaced plantar segment was rotated, seemingly paradoxically into varus, in order to realign the articular surface of the first metatarsal head, especially if the articular surface was pointing in valgus (increased distal metatarsal articular angle) (Figure 2). Surgical correction was performed under fluoroscopic control at each stage of the procedure. Fixation was placed while the osteotomy was held with an offset bone clamp using a cannulated self-compressing screw in the distal metaphysis and a 2.0 cortical screw in the mid-diaphysis. The overhanging dorsal segment of the distal metaphysis and diaphysis were resected. This fragment was placed as a graft into the defect under the proximal portion of the osteotomy. Soft tissue alignment of the hallux was then done by suturing the capsular and periosteal flaps with a series of 0-Vicryl figure-of-eight sutures, while holding the hallux in the corrected position, in a modification of the modified McBride soft tissue realignment, again checking hallux position with fluoroscopy. The skin was closed and the patients were kept in a rigid-soled surgical shoe for 1 month non-weight-bearing, followed by a second month fully weight-bearing. Radiographs were repeated at intervals postoperatively (Figure 3).

Results

Clinical Outcome Scores

The mean preoperative AOFAS score improved significantly from a preoperative value of 52 ± 15.1 (range, 14-88) to a postoperative value of 88 ± 11.8 (range, 45-100) ($P < .05$) at last follow-up. The mean SF-36 physical component summary improved significantly from a preoperative value of 46 ± 8.9 (range, 26-60) to a postoperative value of 52 ± 7.3 (range, 29-60) ($P < .05$) at last follow-up. The SF-36 mental component summary was essentially unchanged from a preoperative value of 54.8 ± 6.8 (range, 36-66) to a postoperative value of 54.6 ± 6.9 (range, 35-67). The mean VAS pain score improved significantly from a preoperative value of 5.8 (range, 2-9.5) to a postoperative value of 1.1(range, 0-6) ($P < .05$) at last follow-up (Table 2).

Radiographic Results

The mean preoperative HVA decreased from 29 ± 8.7 degrees (range, 12-60 degrees) to an initial postoperative value of 10.7 ± 4.4 degrees (range, 3-23 degrees), and the most recent follow-up was maintained at 10.6 ± 7.7 degrees (range, –13 to 25 degrees) The mean preoperative first-second IMA decreased from 13.6 ± 2.6 degrees (range, 6-20 degrees) to 5.6 ± 4.9 degrees (range, 0-13 degrees) at initial follow-up but at most recent follow-up had regressed somewhat to 7.8 ± 2.9 degrees (range, 1-15 degrees). The mean MSP was corrected from an average position of 2.3 (range, 1-3) preoperatively to a value of 0.5 (range, 0-2) at initial follow-up but regressed somewhat at most recent follow-up to 0.9 (range, 0-2) ($P < .05$) (Table 3 and Figure 4).

There were 8 feet (15%) with complications. Four patients had symptomatic hardware, 2 feet had hallux varus, and 2 feet had postoperative progression of first metatarsophalangeal joint arthritis. There were no feet with recurrent hallux valgus.

Reoperations were performed for all 4 feet (8%) with symptomatic hardware to remove the painful screws. The 2 cases of hallux varus (HVA of −8 and −13) did not require reoperation. The 2 cases of first MTP arthritis were apparent on radiographic review but were asymptomatic.

Discussion

Many operative techniques have proven to be successful in the treatment of hallux valgus, and scarf osteotomy has been advocated to be one of those surgical options that is sufficiently powerful to correct moderate to severe hallux valgus. Results from previous studies of correction of hallux valgus using the scarf osteotomy have shown clinical pain relief and functional improvement as well as correction of the radiographic measures of HVA, IMA, and MSP, both compared with preoperative values as well as with values within normal range.[1-3,9,10,25,31]

With the exception of the Mental Component Summary of the SF-36, which was essentially unchanged, all of the prospectively gathered clinical outcomes showed statistically significant improvement, including the AOFAS score,

Figure 2. Weight-bearing anteroposterior radiographs of hallux valgus in a 55-year-old female. (A) Preoperative radiograph: hallux valgus angle (HVA), 36 degrees; intermetatarsal angle (IMA), 13 degrees; medial sesamoid position (MSP), grade 3. (B) Postoperative radiograph: HVA, 13 degrees; IMA, 3 degrees; MSP, grade 1. (C) Last follow-up 51 months: HVA 13, degrees; IMA, 5 degrees; MSP, grade 1.

Figure 3. Intraoperative photo of scarf osteotomy. Medial view of scarf osteotomy prior to fixation. The elevator pushes the osteotomy into mild varus in order to realign the distal articular surface of the metatarsal.

Table 2. Scarf Clinical Outcomes[a]

	Preoperative	Final Follow-Up	*P* Value
AOFAS			
Pain	21.4 (9.1)	34.3 (7.2)	<.00001
Function	5.1 (1.1)	6.5 (1.2)	<.00001
Alignment	1.4 (3.9)	14 (2.7)	<.00001
Total	52 (15.3)	88 (11.8)	<.00001
SF-36			
Physical component summary	46 (8.9)	52 (7.3)	<.00001
Mental component summary	54.8 (6.8)	54.6 (6.9)	.4
Visual analog scale	5.8 (1.9)	1.1 (1.4)	<.00001

[a]Values in parentheses are standard deviation.

the SF-36 physical component summary, and the VAS pain scale. Despite the limitations of the AOFAS scores,[17,28] there is still some value to allow comparison to previous literature. Previous studies report postoperative mean AOFAS scores from 86 to 96.1, which were comparable to the results of this study.[1-3,6-9,15,16,19,21,24,30]

Previous studies of the scarf osteotomy demonstrated mean HVA correction ranging from 15 to 26 degrees and mean IMA correction from 6 to 10 degrees, which were comparable to our findings of mean correction of the HVA of 19 degrees and mean correction of the IMA of about 6 degrees.[6,13,16,21]

We found interesting the comparison of radiographic results in the initial postoperative period with those at last follow-up. Although the correction of the HVA was maintained, there were mild regressions of the IMA and the MSP. There was a mean loss of correction of the IMA of 2.2 degrees and a mean loss of MSP of 0.4 grades (Table 3). Although these regressions between the postoperative and last follow-up radiographs were statistically significant, they were not shown to be clinically meaningful, as they did not correspond to reduction in the clinical outcome measures. We were surprised not to see some loss of HVA. We believe that this is explained by the high rate (23/53 = 43%) of modified Akin medial closing-wedge osteotomies of the first proximal phalanx. This rate of phalangeal osteotomy is comparable to numerous previous reports of scarf osteotomy.[1,6,13,15,24] Phalangeal osteotomy would affect the measurement radiographically of the HVA, but since recurrence

Table 3. Scarf Radiographic Results

	Preoperative	Postoperative	Final Follow-Up	*P* Value,[a] Preoperative vs Postoperative	*P* Value,[b] Preoperative vs Final Follow-Up	*P* Value,[c] Postoperative vs Final Follow-Up
Hallux valgus angle, degrees, mean (SD)	29 (8.7)	10.7 (4.4)	10.6 (7.7)	.00002	.0000005	.3
Intermetatarsal angle, degrees, mean (SD)	13.6 (26)	5.6 (4.9)	7.8 (2.9)	.00008	.00000017	.00005
Medial sesamoid position, degrees, mean (SD)	2.3 (0.7)	0.5 (0.5)	0.9 (0.7)	.00004	.000000003	.00012

[a]*P* values compare preoperative and postoperative.
[b]*P* values compare preoperative and final follow-up.
[c]*P* values compare postoperative and final follow-up.

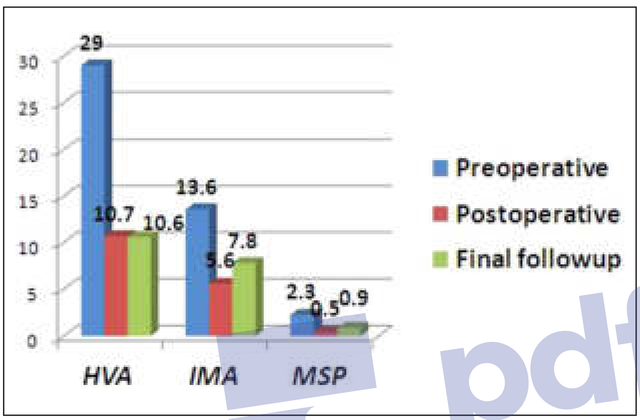


Figure 4. Graph of radiological changes. Preoperative, postoperative, and final-follow-up data are shown for hallux valgus angle (HVA), intermetatarsal angle (IMA), and medial sesamoid position (MSP).

or regression usually occurs through soft tissue stretching at the first MTP joint, the modified Akin phalangeal osteotomy would counterbalance that.

To the best of our knowledge, no other studies of the scarf osteotomy, and very few studies of hallux valgus surgery using other techniques, have measured and analyzed statistically the maintenance of or loss of radiographic correction between the initial postoperative period and at later follow-up. But it is well-known surgical wisdom that mild regression of either hallux valgus (HVA) or first metatarsal varus (IMA) is sufficiently common as to be the rule rather than the exception, even though most regressions are radiographic but subclinical and either asymptomatic or insufficiently symptomatic to warrant operative revision. It is important and valuable to document these changes because they predict and quantify the natural course of hallux valgus surgery in general. This idea is obscured in most studies of hallux valgus surgery because correction is measured postoperatively at a single point in time. The statistical analysis of these radiographic measures showed that the corrections at final follow-up, when compared with preoperative values, were still statistically significantly improved (*P* value,[b] preoperative and final follow-up) and corresponded to the satisfactory clinical outcomes at final follow-up.

Cadaveric studies have confirmed that scarf osteotomy has double the stability of distal chevron osteotomy or a proximal crescentic osteotomy.[20,29] Although the scarf osteotomy is an effective technique for hallux valgus deformity correction, providing pain improvement, complications of this procedure have been reported to be as low 1%[2] and as high as 47%,[4] although most studies report moderate rates of complications ranging between 4% and 18%, depending on the author, technique, and criteria.[1-3,6-9,11-16,19,21,24-26,30,31] The complication rate in this study is comparable to the majority of prior studies.

The osteotomy, also called a scarf, as depicted in the study by Coetzee,[4] is radically different than the proper configuration of a scarf osteotomy as we understand it. The difference is the extension of the osteotomy into the distal metaphysis of the first metatarsal, which is essential to prevent troughing. Our complication rate was 15%, which is consistent with other studies. Most of our complications in this early series with our experience with the scarf osteotomy were related to the placement of internal fixation and were attributable to our learning curve. The 2 cases of hallux varus were not sufficiently symptomatic to the patients to warrant revision, despite offers to do so, and both cases of first MTP arthritis are asymptomatic to date.

There were 2 feet with asymptomatic, flexible hallux varus, measuring −8 and −13 degrees HVA, respectively. No further operative procedure was desired by these 2 patients. The literature reports that the most common operative cause is excessive resection of the first metatarsal head, excessive medial capsulorrhaphy, and overcorrection of the intermetatarsal angle.[22] We attribute the varus in the first case (−8 degrees) to overtightening the medial capsule. In the second case (−13 degrees), the varus appears to have been influenced by progressive varus deformity of the second MTP joint, which the patient elected not to have corrected but which progressed postoperatively. Weil[30] reported an 8% rate of hallux varus, of which 3% did not require reoperation. Zygmunt et al[31] reported (3%) hallux varus in 2 of 66 cases.

This series had 2 cases (4%) with postoperative first MTP arthritis, which were asymptomatic at the time of last follow-up but which may eventually require arthrodesis. Crevoisier et al[6] reported 2% (2/84) with painful first MTP arthritic change at 12 month follow-up, both requiring arthrodesis.[30] Berg et al[3] reported MTP arthritis in 2 of 72 cases (3%) at a comparable 24 month follow-up, which required arthrodesis at 36 months.

Conclusion

Hallux valgus correction using the scarf osteotomy with soft tissue realignment produced satisfactory clinical and radiographic results in this series. The technique was reliable and had an acceptable rate of complications and a low incidence of recurrence at intermediate follow-up.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Adam SP, Choung SC, Gu Y, O'Malley MJ. Outcomes after scarf osteotomy for treatment of adult hallux valgus deformity. *Clin Orthop Rel Res*. 2011;469:854-859.
2. Aminian A, Kelikian A, Moen T. Scarf osteotomy for hallux valgus deformity: an intermediate followup of clinical and radiographic outcomes. *Foot Ankle Int*. 2006;27:883-886.
3. Berg RP, Olsthoorn PG, Poll RG. Scarf osteotomy in hallux valgus: a review of 72 cases. *Acta Orthop Belgica*. 2007;73:219-223.
4. Coetzee JC. Scarf osteotomy for hallux valgus repair: the dark side. *Foot Ankle Int*. 2003;24:29-33.
5. Coetzee JC, Rippstein P. Surgical strategies: scarf osteotomy for hallux valgus. *Foot Ankle Int*. 2007;28:529-535.
6. Crevoisier X, Mouhsine E, Ortolano V, Udin B, Dutoit M. The scarf osteotomy for the treatment of hallux valgus deformity: a review of 84 cases. *Foot Ankle Int*. 2001;22:970-976.
7. Gupta S, Fazal MA, Williams L. Minifragment screw fixation of the Scarf osteotomy. *Foot Ankle Int*. 2008;29:385-389.
8. Hammel E, Abi Chala ML, Wagner T. Complications of first ray osteotomies: a consecutive series of 475 feet with first metatarsal scarf osteotomy and first phalanx osteotomy. *Rev Chir Orthop Reparatrice Appar Mot*. 2007;93:710-719.
9. Jones S, Al Hussainy HA, Ali F, Betts RP, Flowers MJ. Scarf osteotomy for hallux valgus: a prospective clinical and pedobarographic study. *J Bone Joint Surg Br*. 2004;86:830-836.
10. Kilmartin TE, Barrington RL, Wallace WA. Metatarsus primus varus: a statistical study. *J Bone Joint Surg Br*. 1991; 73:937-940.
11. Kitaoka HB, Alexander IJ, Adelaar RS, et al. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int*. 1994;15:349-353.
12. Kramer J, Barry LD, Helfman DN, Mehnert JA, Pokrifcak VM. The modified scarf bunionectomy. *J Foot Surg*. 1992;31:360-367.
13. Kristen KH, Berger C, Stelzig S, et al. The scarf osteotomy for the correction of hallux valgus deformities. *Foot Ankle Int*. 2002;23:221-229.
14. Larholt J, Kilmartin TE. Rotational scarf and akin osteotomy for correction of hallux valgus associated with metatarsus adductus. *Foot Ankle Int*. 2010;31:220-228.
15. Lipscombe S, Molloy A, Sirikonda S, Hennessy MS. Scarf osteotomy for the correction of hallux valgus: midterm clinical outcome. *J Foot Ankle Surg*. 2008;47:273-277.
16. Lorei TJ, Kinast C, Klarner H, Rosenbaum D. Pedographic, clinical, and functional outcome after scarf osteotomy. *Clin Orthop Rel Res*. 2006;451:161-166.
17. Madeley NJ, Wing KJ, Topliss C, et al. Responsiveness and validity of the SF-36, Ankle Osteoarthritis Scale, AOFAS Ankle Hindfoot Score, and Foot Function Index in end stage ankle arthritis. *Foot Ankle Int*. 2012;33:57-63.
18. Miller JW. Distal first metatarsal displacement osteotomy: its place in the schema of bunion surgery. *J Bone Joint Surg Am*. 1974;56:923-931.
19. Murawski CD, Egan CJ, Kennedy JG. A rotational scarf osteotomy decreases troughing when treating hallux valgus. *Clin Orthop Rel Res*. 2011;469:847-853.
20. Newman AS, Negrine JP, Zecovic M, Stanford P, Walsh WR. A biomechanical comparison of the Z step-cut and basilar crescentic osteotomies of the first metatarsal. *Foot Ankle Int*. 2000;21:584-587.
21. Perugia D, Basile A, Gensini A, Stopponi M, Simeonibus AU. The scarf osteotomy for severe hallux valgus. *Int Orthop*. 2003;27:103-106.
22. Plovanich EJ, Donnenwerth MP, Abicht BP, et al. Failure after soft-tissue release with tendon transfer for flexible iatrogenic hallux varus: a systematic review. *J Foot Ankle Surg*. 2012;51:195-197.
23. Ptaszek AJ, Morris SG, Brodsky JW. Midfoot field block anesthesia with monitored intravenous sedation in forefoot surgery. *Foot Ankle Int*. 1999;20:583-586.
24. Robinson AH, Bhatia M, Eaton C, Bishop L. Prospective comparative study of the scarf and Ludloff osteotomies in the treatment of hallux valgus. *Foot Ankle Int*. 2009;30:955-963.
25. Schoen NS, Zygmunt K, Gudas C. Z-bunionectomy: retrospective long-term study. *J Foot Ankle Surg*. 1996;35: 312-317.

26. Smith AM, Alwan T, Davies MS. Perioperative complications of the scarf osteotomy. *Foot Ankle Int*. 2003;24:222-227.
27. Smith RW, Reynolds JC, Stewart MJ. Hallux valgus assessment: report of research committee of American Orthopaedic Foot and Ankle Society. *Foot Ankle Int*. 1984;5:92-103.
28. SooHoo NF, Shuler M, Fleming LL. Evaluation of the validity of the AOFAS Clinical Rating Systems by correlation to the SF-36. *Foot Ankle Int*. 2003;24:50-55.
29. Trnka HJ, Parks BG, Ivanic G, et al. Six first metatarsal shaft osteotomies: mechanical and immobilization comparisons. *Clin Orthop Rel Res*. 2000;(381):256-265.
30. Weil LS. Scarf osteotomy for correction of hallux valgus: historical perspective, surgical technique, and results. *Foot Ankle Clin*. 2000;5:559-580.
31. Zygmunt KH, Gudas CJ, Laros GS. Z-bunionectomy with internal screw fixation. *J Am Podiatr Med Assoc*. 1989;79:322-329.