Biplane Cuneiform Osteotomy for Juvenile Metatarsus Primus Varus

An operation combining the procedures of Cotton and Fowler on the medial cuneiform has been used for the correction of juvenile metatarsus primus varus and is presented in this manuscript. The procedure consists of a biplanar opening wedge osteotomy of the medial cuneiform with insertion of a bone graft and internal fixation. This surgical approach evolves from the procedures of Cotton (a sagittal plane correction of the depressed distal medial column in pes planus), and Fowler (a transverse plane correction of the medial column for metatarsus adductus). The operation has been utilized at St. Anne's Hospitals and provides excellent reduction of the intermetatarsal angle, with realignment of an oblique metatarsal-cuneiform joint. The operation is done with the Hohmann osteotomy/bunionectomy for realignment of the metatarsophalangeal joint to correct hallux valgus that exists with juvenile metatarsus primus varus.

Brian Edward Bacardi, D.P.M.[1]
Jared P. Frankel, D.P.M., F.A.C.F.S.[2]

The combination of two surgical procedures into one has been employed as a means of correcting juvenile metatarsus primus varus deformity. Cotton's opening wedge osteotomy of the medial cuneiform with insertion of bone graft is a sagittal plane structural correction of the depressed medial column of the arch in pes planus (1). Fowler's opening wedge medial cuneiform osteotomy with insertion of bone graft is a transverse plane structural correction of the medial column in metatarsus adductus (2). A biplanar modification of these procedures in conjunction with metatarsal osteotomy has been employed at St. Anne's Hospitals for correction of juvenile metatarsus primus varus with hallux valgus deformity.

The operation is performed with the Hohmann osteotomy/bunionectomy (3) to alter the proximal articular set angle by realigning the adapted articular cartilage of the first metatarsal head. The capital fragment is also transposed lateral for intermetatarsal angle correction, and plantar, to overcome the elevation of the metatarsal that is often seen with a hypermobile first ray in juvenile hallux valgus. The plantar repositioning also compensates for the shortening of the metatarsal that accompanies the osteotomy.

The biplane cuneiform operation is indicated in order to correct the following: juvenile metatarsus primus varus (Fig. 1*A*); oblique metatarsal-cuneiform articulation, as seen on the dorsoplantar weight-bearing radiograph (Fig. 1*B*); and depression of the distal-medial arch (Fig. 2).

The operation affords correction at the apex of the deformity, differing from metatarsal base osteotomies, which are distal to the deformity. Double osteotomy is necessary to correct two deformities, i.e., the intermetatarsal angle and the proximal articular set angle, yet the procedure preserves the length of the first metatarsal. By increasing the height of the distal-medial arch, and the forward inclination of the metatarsal-cuneiform joint in the sagittal plane, it enhances the durability of correction against recurrence from continued pronatory stress in the flatfoot. The transverse plane component closes the intermetatarsal angle and decreases the influence of retrograde buckling of the metatarsal on the metatarsal-cuneiform articulation.

Lapidus believed that the deformity of the first ray was evidence of an atavistic foot. He suggested that the congenital "metatarsus varus primus" is the primary deformity leading to a secondary formation of hallux valgus (4). He stated further that the medial opening at the first metatarsal-cuneiform articulation causes a compensatory angulation open laterally between the hallux and the first metatarsal. This, he reasoned, is analagous to the dorsal kyphosis of the spine being compensated by an increased lumbar lordosis. Lapidus believed osteotomy should be made at the apex of the angulation.

"No one would try to correct a knock-knee by osteotomizing at the middle of the tibia or the femur. It is treated by an osteotomy as near the joint as possible. Therefore, the only mechanically sound osteotomy for

From the Department of Orthopedic Surgery, Section of Podiatric Surgery, St. Anne's Hospitals, Northlake and Chicago, Illinois
[1] Submitted while Senior Surgical Resident. Address Correspondence to: 108 N. Spring Street, Manchester, Tennessee 37355.
[2] Director, Residency Training Program.
0449/2544/86/0256-0472$02.00/0

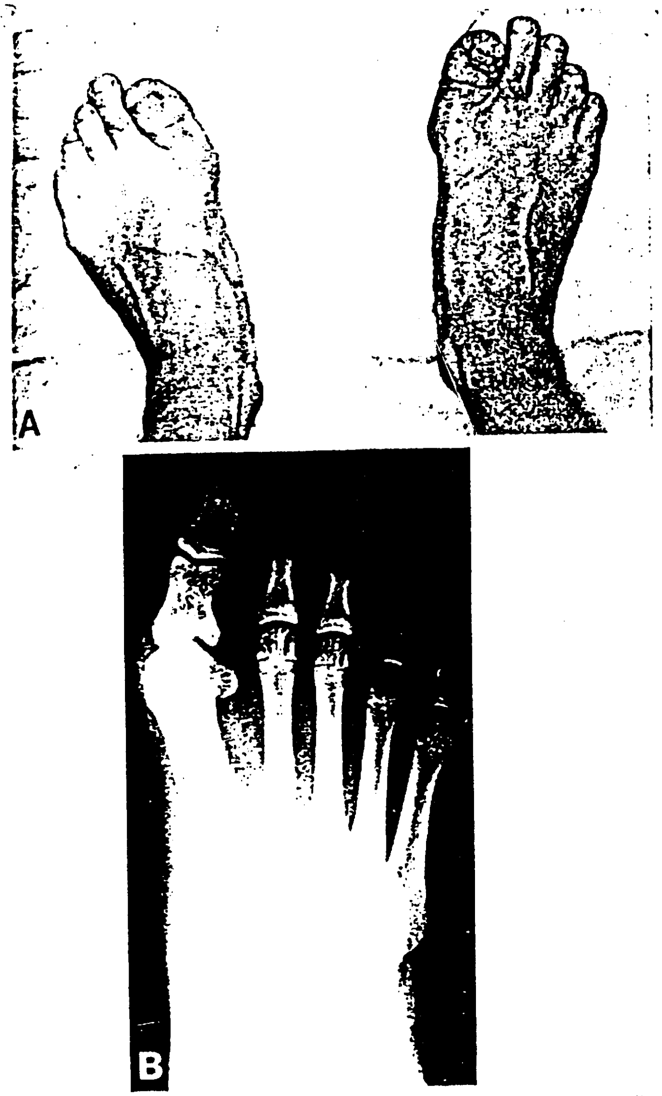


Figure 1. *A*, juvenile metatarsus primus varus noted clinically; *B*, anteroposterior view of right foot exhibiting an oblique metatarsal-cuneiform articulation creating the deformity.

correction of metatarsus varus primus should be located at the first cuneo-metatarsal joint, which is the apex of the angulation" (4).

Albrecht, in 1911, was the first to recommend resection and fusion of the metatarsal-cuneiform joint for hallux valgus (5). Later, Kleinberg recommended wedge resection and fusion of the joint (6). Lapidus added fusion of the bases of metatarsals one and two with packing of bone chips in the opening between the bases (4).

Although the mechanics of metatarsus primus varus presented by Lapidus are sound, intermetatarsal angle reduction in young patients is usually not done by his method. Postoperative morbidity is lessened by utilizing osteotomy of the first metatarsal. In elderly patients,

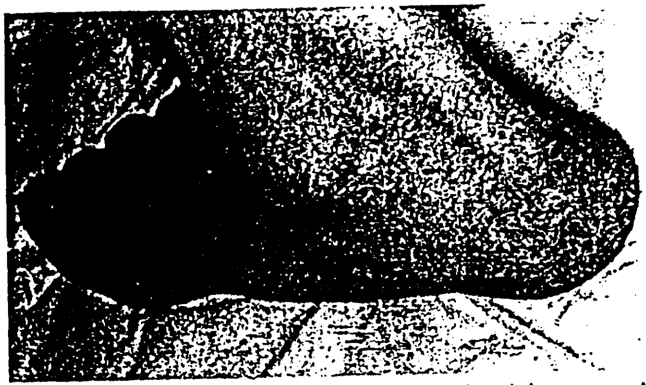


Figure 2. The depressed medial longitudinal arch is apparent.

the bone stock is of concern in that it must be adequate to heal a fusion in a reasonable length of time because prolonged immobilization can create further problems.

McCrea and Lichty studied the relationship between obliquity of the articular surfaces of the metatarsal-cuneiform joint and adduction of the first metatarsal (7). Roentgenographic analysis of over 300 sets of feet revealed that a greater obliquity of the joint resulted in an increased intermetatarsal angle. Haines and McDougall stated that normal feet have a more transverse setting of the metatarsal-cuneiform joint (8). The amount of obliqueness was determined in an anatomic study.

The statistical findings of McCrea and Lichty support the morphologic findings of Haines and McDougall. The former hypothesized that perhaps the medial aspect of the epiphysis of the first metatarsal may not be stimulated by retrograde forces that are normally present. They also noted an increase in length of the lateral surface of the first metatarsal compared to the length of the medial surface. In accordance with Wolff's law, altered growth could occur at the epiphysis of the bone, giving rise to length discrepancies between the medial and lateral aspects of the metatarsal shaft. The authors suggested the Ellis procedure, epiphysiodesis of the lateral portion of the growth plate in skeletally immature patients.

This procedure is usually combined with distal osteotomy to realign the joint. After the Ellis procedure, and with continued skeletal growth, reduction of the intermetatarsal angle should progress until closure of the medial epiphysis. In feet with a large metatarsus primus varus and markedly oblique metatarsal-cuneiform articulations, the epiphysiodesis operation would not provide adequate correction.

The foot deformities amenable to a combined biplane cuneiform osteotomy with a Hohmann osteotomy have often been addressed simply by closing base wedge osteotomy and/or distal osteotomy of the first metatarsal. In the interest of preserving the length of the metatarsal, a crescentic osteotomy or an opening wedge osteotomy with bone graft may be utilized. These may be combined with a distal metatarsal osteotomy for correction of the proximal articular set angle. Although opening wedge osteotomy is considered preoperatively, the biplane cuneiform osteotomy appears to be a superior method for effecting correction of the intermetatarsal angle while maintaining length.

Operative Technique

The medial cuneiform is approached through a serpentine incision (Fig. 3). The tibialis anterior tendon, coursing inferiorly, is retracted, and the metatarsal-cuneiform joint (anteriorly) and navicular-cuneiform joint (posteriorly) are identified. A dorsomedial osteotomy is directed 15 degrees forward from the vertical, 1 cm. proximal to the metatarsal-cuneiform joint. The lateral cortex is left intact (Fig. 4). The osteotomy is pried open and movement at the distal aspect is biplanar. The intermetatarsal angle is reduced through lateral motion and the bones angle plantarly, owing to the pivoting as the osteotomy is opened. This effects an increase in the downward pitch of the metatarsal. An appropriately sized wedge of homologous or autogenous bone is impacted securely and maintained with a bone staple placed dorsomedially (Fig. 5). The Hohmann osteotomy/bunionectomy is then performed and fixated with a bone screw.

Correction of tailor's bunion deformity may be required with a concomitant splay forefoot. Gastrocnemius recession or lengthening of the Achilles tendon is often required to correct the ankle equinus usually accompanying juvenile metatarsus primus varus.

Postoperatively, the patient should be maintained nonweightbearing for 4 to 6 weeks. Progressive weightbearing, protected by a cast or removable splint, is allowed during the next 6 weeks (Fig. 6). Bilateral cases should be separated by approximately 4 months. After convalescence, all patients are maintained in properly posted orthoses. (Fig. 7).

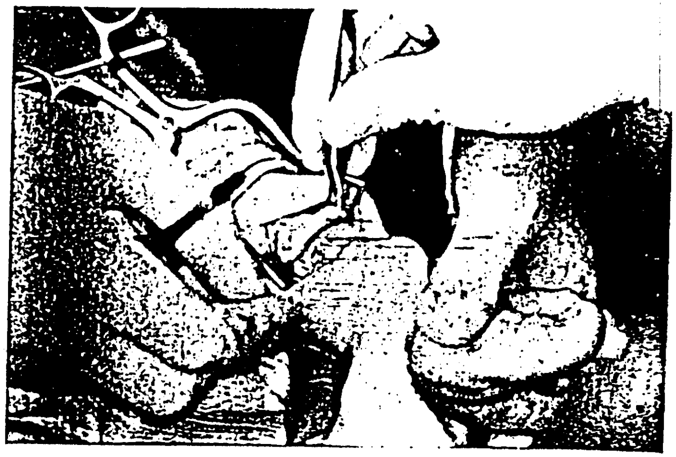


Figure 4. The osteotomy is inclined forward approximately 15 degrees. It is pried open, effecting a biplanar angulation of the distal segment, closing the intermetatarsal angle, and increasing the declination of the first metatarsal.

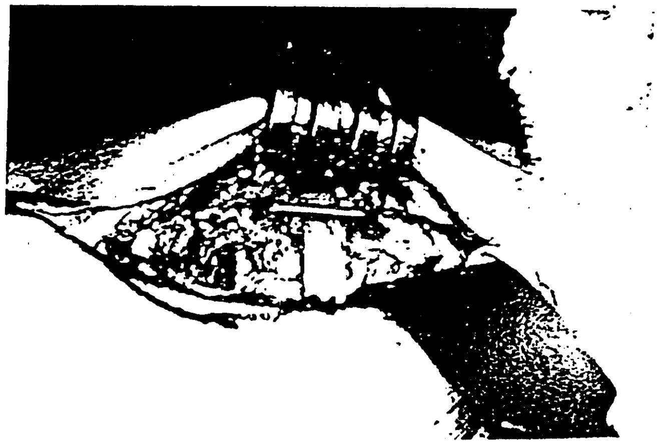


Figure 5. An appropriately wedged bone graft is fit and secured with a staple.

Figure 3. Serpentine incision providing exposure required for visualizing the inferomedial aspect of the cuneiform as well as the dorsal aspect of the first metatarsal and interspace.

Electrodynagraphic Analysis

Patients undergoing this operation possessed a moderate to marked pes planus with splay forefoot. Patients exhibited a compensated forefoot varus with calcaneal stance position of moderate eversion (3 to 6 degrees). The first and fifth rays were hypermobile, as is indicated by preoperative electrodynagraphic (EDG) tracings[3]

[3] Electrodynagram— The Langer Biomechanics Group, Inc., 21 East Industry Court, Deer Park, N. Y.

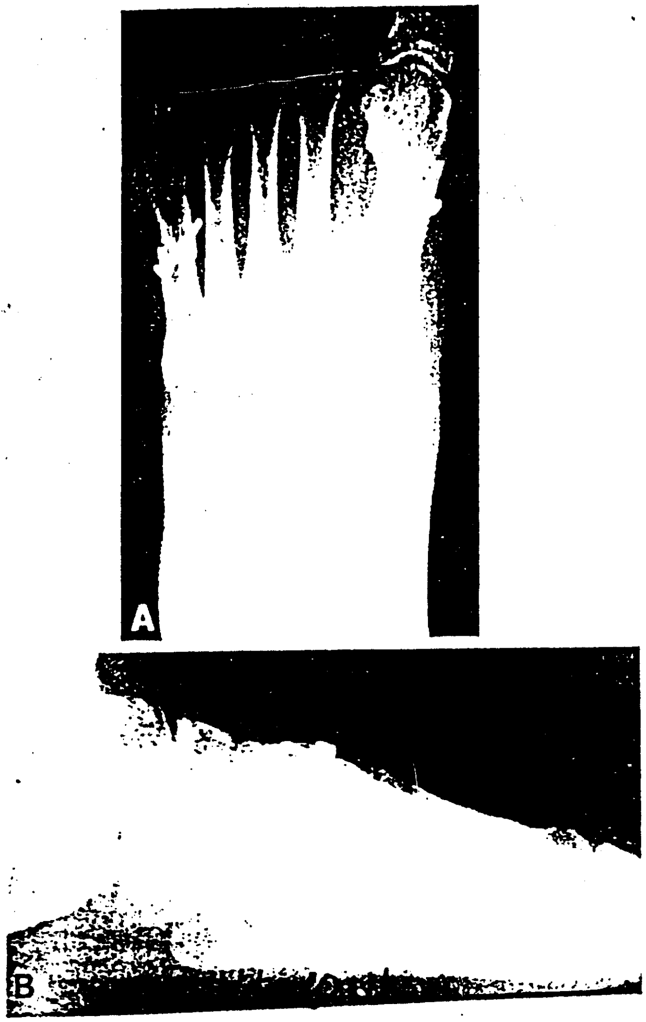


Figure 6. Postoperative radiographs at 10 weeks indicating healing of the osteotomy sites. *A*, anteroposterior view; *B*, lateral view.

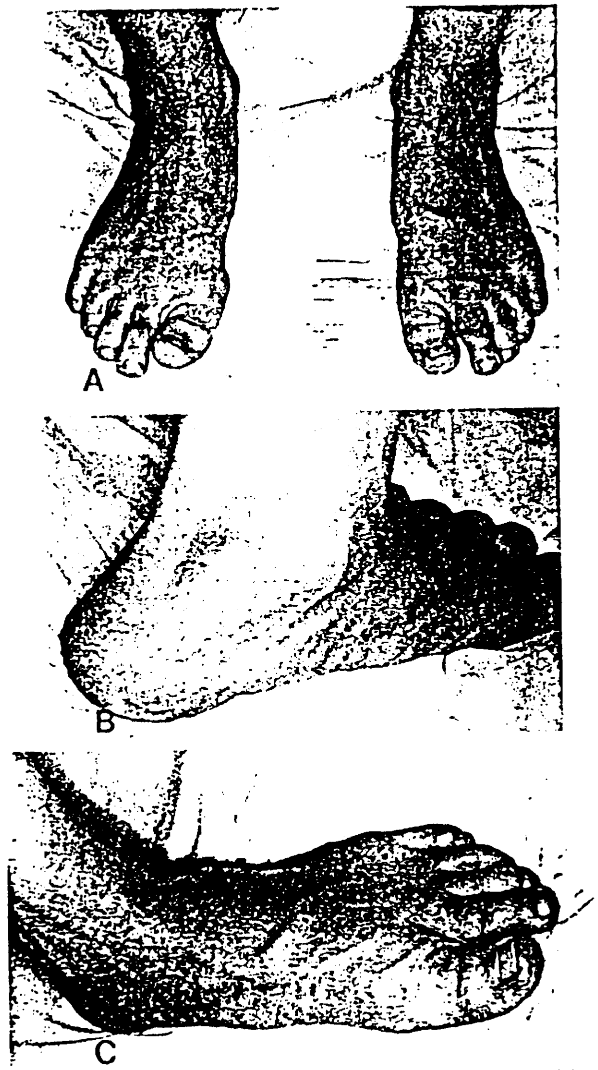


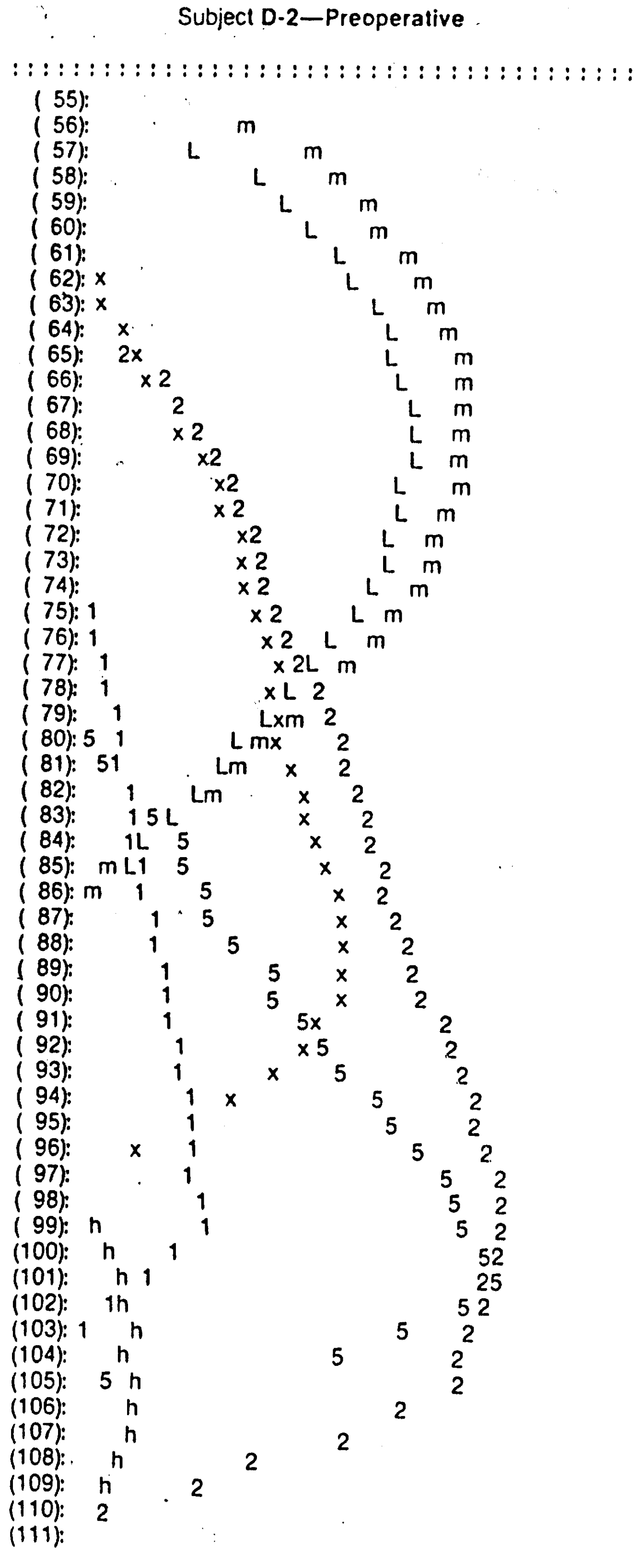
Figure 7. Clinical appearance of the left foot to coincide with Figure 6. *A*, dorsal view; *B*, *C*, side views.

These rays accepted conspicuously less than normal load during midstance and early propulsive phases of gait. The second and fourth metatarsal heads underwent loading well before, and to a much greater degree than, the first and fifth. In fact, the fifth metatarsal frequently did not load until well after the second metatarsal, and by this time in the cycle, it was already the propulsive phase.

Postoperatively, the EDG tracings indicated a significant alteration in weightbearing of the forefoot. The fifth metatarsal would load soon after the fourth metatarsal, and the first metatarsal usually preceded loading of the second metatarsal. Both the first and fifth metatarsals bore weight relatively earlier in the stance phase. The first metatarsal also loaded to a greater extent than preoperatively. The fifth metatarsal, postoperatively, demonstrated a smooth loading curve through midstance and into midpropulsion. This is present in a more normal functioning foot and represents an improvement from the preoperative curve, which showed an abrupt loading of the fifth metatarsal in the midpropulsive phase of gait.

The postoperative electrodynagraphic findings corresponded with the clinical and roentgenographic examinations. These demonstrated increased plantar declination of the first ray, attributable to the biplane cuneiform and Hohmann operations. A concomitant tailor's bunion deformity was eliminated with a biplane distal osteotomy of the fifth metatarsal and plantar-medial transposition of the capital fragment.

Postoperatively, the loading of the first metatarsal is markedly earlier in stance phase, and to a greater extent. The fifth metatarsal loads earlier in the cycle, and demonstrates the smoother, more normal loading



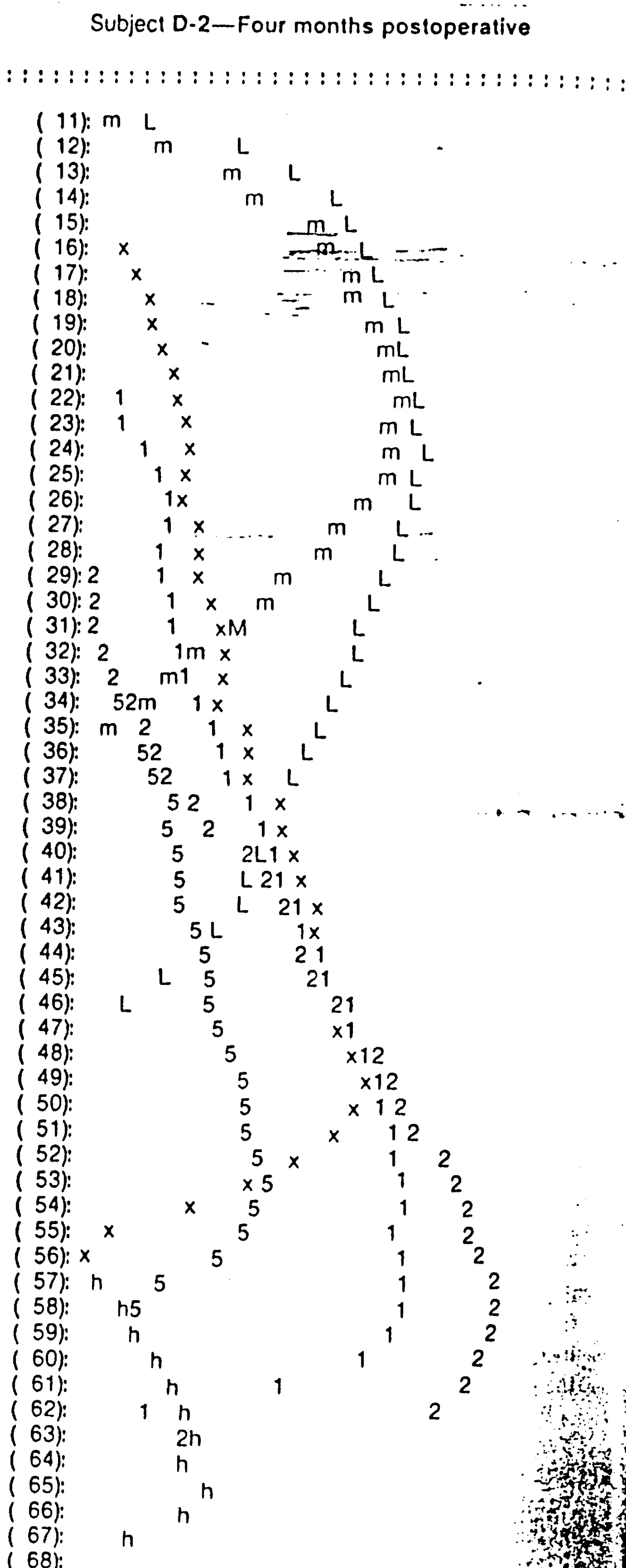


Figure 8. Electrodynagraphic recordings of operated feet. Preoperatively, metatarsals one and five accept less than normal loading during midstance and early propulsion phases, whereas metatarsals two and four undergo loading well before, and to a greater extent. This corresponded with clinical examination that indicated hypermobility of the first and fifth rays.

Subject K-1—Preoperative

```
( 62):                 m
( 63):        L               m
( 64):               L            m
( 65):                   L        m
( 66):                       L      m
( 67):                         L      m
( 68):                          L      m
( 69):  x                         L     m
( 70):      x                       L     m
( 71):        x                      L    m
( 72):  2       x                     L
( 73):    3      x                     Lm
( 74):        2  x                     L m
( 75):        2    x                 L m
( 76):         2    x                L m
( 77):            2   x           Lm
( 78):             2     x       Lm
( 79):              2      x   Lm
( 80):                2     x m
( 81):                 2 Lmx
( 82):                  2 m    x
( 83): 1              L 2      x
( 84): 5          L m    2      x
( 85): 1        L m       2     x
( 86): 15       m           2   x
( 87): 1      m             2   x
( 88): 51  mL                2    x
( 89): 15m                   2   x
( 90): m1L                    2 x
( 91): mL51                   2 x
( 92):  1                     2 x
( 93):  51                     2
( 94):  51                    x2
( 95):  5 1                   x   2
( 96):   5 1                x     2
( 97):    5 1              x         2
( 98):     51              x          2
( 99):      51          x             2
(10C):       51      x                2
(101):          1  x                     2
(102):        x1    5                    2
(103): h   x      1    5                   2
(104): h x       1     5                    2
(105): h         1      5                   2
(106): h        1           5                 2
(107):  h      1          5                2
(108):   h    1           5                 2
(109):    h 1     5                         2
(110): 5  h                               2
(111):  1   h                            2
(112):     h                          2
(113):      h                      2
(114):       h                 2
(115):      h          2
(116):     h2
(117):  2h
(118): h
(119):
```

Subject K-1—Six months postoperative

```
(  7):     L
(  8):        m          L
(  9):                  m     L
( 10):                           mL
( 11):  x                            mL
( 12):    x                            m
( 13):     x                             Lm
( 14):        x                           L m
( 15):         x                          L m
( 16):         x                          L m
( 17):           x                          L m
( 18):            x                         L m
( 19):            x                         L m
( 20): 5          x                         L m
( 21): 5          x                         L m
( 22): 1            x                       L m
( 23): 1            x                       L m
( 24):  1           x                       L m
( 25):   15         x                       L m
( 26):    1         x                      L m
( 27):     5 1      x                      L m
( 28):    5   1      x                     L m
( 29):   25        1 x                    L m
( 30):   25        1                    L m
( 31):    2           x1                L m
( 32):     52        x   1           L m
( 33):  5   2         x   1          L m
( 34): 5      2       x   1       L      m
( 35):   5      2     x    1     L      m
( 36):      5     2     x      1L       m
( 37):      5       2  x       L1     m
( 38):      5          2 x     L   1m
( 39):      5           2x    L     1
( 40):       5            x 2   m    1
( 41):       5            L x2        1
( 42):       5        L     x 2           1
( 43):         5    L  m    x    2        1
( 44):          5 m         x        2      1
( 45):  m L     5           x       2      1
( 46):            5          x        2       1
( 47):           5           x          2      1
( 48):            5       x              2     1
( 49):            5     x                   2   1
( 50): h         5x                         2   1
( 51): h    x    5                           2  1
( 52):    xh    5                              21
( 53):     h 5                                 1
( 54):   5   h                                 12
( 55):        h                            1     2
( 56):           h                         1    2
( 57):               h                   1     2
( 58):                h            1        2
( 59):                 1h   2
( 60): 1                  h
( 61):                       h
( 62):                h
( 63):         h
( 64):   h
( 65): h
( 66):
```

Numbers *1*, *2*, and *5* are electrode sensors placed beneath metatarsal heads 1, 2, and 5; *x* is a sensor beneath the fourth metatarsal head; *h* is a sensor beneath the hallux; *L* and *m* are sensors beneath the lateral and medial tubercles of the calcaneus, respectively.

curve, an improvement from the late and abrupt loading seen preoperatively (Fig. 8*B* and *D*). Also, postoperatively, less pronatory eversion was noted at the heel. The lateral heel sensor demonstrated loading that more closely approximates (Fig. 8*D*) or exceeds the load acceptance under the medial tubercle (Fig. 8*B*).

Summary

The biplane cuneiform osteotomy operation has been described, and the technique has been detailed and illustrated. Rationale for its implementation has been presented, including the purposes and indications for its selection. The authors regard it as a superior technique for intermetatarsal angle reduction and realignment of the first metatarsal cuneiform joint in juvenile metatarsus primus varus. Electrodynagraphic analysis indicates improved function of the feet postoperatively in the stance phase of gait. Better loading of the first ray is demonstrated. Postoperative radiographic evaluation also demonstrates marked improvement in the forefoot. Clinical evaluations have been encouraging.

References

1. Cotton, F. J. Foot statics and surgery. Tr. N. Engl. Surg. Soc. 18:181, 1935.
2. Fowler, B., Brooks, A. L., and Parrish, T. F. The cavovarus foot. J. Bone Joint Surg. 41A:757, 1959.
3. Hohmann, G. Zur Hallux Valgus Operation. Zentralbl. Chir. 51:230, 1924.
4. Lapidus, P. W. Operative correction of the metatarsus varus primus in hallux valgus. Surg. Gynecol. Obstet. 58:184, 1934.
5. Albrecht, G. H. The pathology and treatment of hallux valgus. Russ. Vrach. 10:14, 1911.
6. Kleinberg, S. Operative cure of hallux valgus and bunions. Am. J. Surg. 15:75, 1932.
7. McCrea, J. D., and Lichty, T. K. The first metatarsocuneiform articulation and its relationship to metatarsus primus adductus. J. A. P. A. 69:700, 1979.
8. Haines, R., and McDougall, A. The anatomy of hallux valgus. J. Bone Joint Surg. 36B:2, 1954.

Additional References

Kelikian, H. *Hallux Valgus, Allied Deformities of the Fore-Foot and Metatarsalgia*, pp. 166–169, 199, 200, 241–244, W. B. Saunders, Philadelphia, 1965.

Comment: The authors describe a biplanar opening wedge osteotomy of the medial cuneiform in combination with a Hohmann-type bunionectomy to correct hallux valgus when seen with juvenile metatarsus primus varus deformity. The authors claim uniqueness in that this manner of correction more accurately addresses the level of deformity, preserves first metatarsal length, and maintains correction by eliminating pronatory medial column deformity.

The procedures outlined certainly serve as food for thought and address a number of concerns commonly seen with these type of deformities. One interesting concept is the importance of effectively dealing with etiologic influences to lessen the chance of recurrence. In this case, etiologic influences are addressed by simultaneous correction of sagittal plane medial column deformity. Although the use of postoperative orthoses can also mitigate deforming influences that can lead to recurrence, orthoses to accomplish this goal and compliance to orthoses is sometimes less than desired. Recognizing that all surgical procedures carry inherent risks, the choice as to whether to correct causative proximal deformities surgically, or to control them by conservative means ultimately rests with the individual practitioner. However, it should be noted that sagittal plane restoration or repositioning of the medial column, by whatever method, carries additional risks when performed as an isolated procedure. It is usually more prudent to perform concurrent procedures that help control subtalar joint pronation, because this usually contributes to excessive medial column loading. Although the authors support their case with electrodynagraphic evaluation, longer term studies would ultimately decide this issue.

The issue of dealing more accurately with the level of deformity is certainly not one to dispute. However, I did have other questions that came to mind when I first read this interesting article. The angular relationships that are often used to determine the appropriate bunion procedures are conspicuously absent. Although this may be a moot point, the x-rays displayed seem to indicate that alternative procedures may have produced intermetatarsal and proximal articular set angle reduction, with restoration of length, and with less surgery. The reverse Wilson procedure would be one such example. However, this admitedly does little to restore the position of the medial column providing it is a main concern. The inclusion of a preoperative lateral x-ray would be useful in assessing the degree of sagittal plane correction that can be achieved with this procedure. Also, shifting of the capital fragment during the modified Hohmann, in combination with the transverse plane correction afforded by a cuneiform osteotomy, appeared redundant unless done for other reasons this reviewer missed.

Lawrence M. Oloff, D.P.M., F.A.C.F.S.