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Osteotomies for Hallux Valgus Correction

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The earliest reports of surgical hallux valgus correction date back to Gernet in 1836. Most popular were the resection of parts of the first metatarsophalangeal (MTP) joint by Mayo [1], Keller [2], and Brandes [3]. Despite the fact that some of these techniques are still in use, they should be abandoned for most patients.

Correctional metatarsal osteotomies are the treatment of choice of the twenty-first century. Our ancestors in the nineteenth century already had this thought. The first reports date back to Reverdin [4], who described a subcapital closing wedge osteotomy for the correction of hallux valgus deformity in 1881. It became popular as the Hohmann [5] osteotomy.

From the beginning of the use of osteotomies for the treatment of hallux valgus deformities, surgeons distinguished between distal and proximal osteotomies. The Hohmann [5], Wilson [6], Mitchell [7], and chevron [8] osteotomies were representatives of the distal osteotomies, whereas the Loison [9], Balacescu [10], Ludloff [11], Trott [12] and crescentic Mann osteotomy [13] were representatives of the proximal osteotomies. One may think that after more than 160 years of hallux valgus surgery, a perfect treatment should have been found. In 1931, Peabody [14] thought that he had found it. He stated that all of his patients were happy and there was no complication; he was wrong. In 1981, Helal [15] counted more than 150 different techniques; the number has increased since that time.

A minimum consensus among surgeons has been established. Minor and moderate deformities (rated by intermetatarsal and hallux valgus angles) may be treated by distal osteotomies. More severe deformities are treated best by proximal metatarsal osteotomies; these have been proven mathematically to give the best corrections.

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This article should shed some light on the numerous metatarsal osteotomies. The author reviewed the results of different metatarsal osteotomies that were performed from 1975 to 1997 and established an algorithm to treat the different forms of hallux valgus deformity.

Distal metatarsal osteotomies

In 1884, Barker [16] was the first person to describe a distal metatarsal closing wedge osteotomy for the correction of hallux valgus deformity. This kind of technique became popular after the description of Hohmann [5] in the German literature in 1921. The downside of the original technique was the necessity of a cast and the resulting shortening of the metatarsal. Therefore, it was modified by Kramer and colleagues [17,18] who replaced the closing wedge osteotomy with a lateral translation osteotomy and added a Kirschner wire fixation. Bösch et al [19] simplified this procedure further by developing a special lever to perform the osteotomy subcutaneously. The advantage of this osteotomy—especially the subcutaneous Bösch osteotomy—is offset by the disadvantage of the inherently unstable osteotomy that is not stable enough to maintain correction without fixation. In 1997, Trnka et al [20] compared the results of the Kramer and the Austin osteotomies. Similar corrections of the hallux valgus angle and intermetatarsal angles were observed in both groups. A statistically better correction of the sesamoid position was seen after the Austin procedure. After the Kramer osteotomy, more malalignment and recurrent severe hallux valgus deformity were seen. Bösch et al [19] reported much better results in a 7- to 10-year follow-up study. Of the 98 feet, the average hallux valgus angle was corrected from 36° preoperatively (range, 14° to 54°) to 19° postoperatively (range, 7° to 40°). The average intermetatarsal angle was corrected from 13° preoperatively (range, 6° to 18°) to 10° postoperatively (range, 3° to 18°). Complications included four deep infections and four cases of delayed bone healing. Bretschneider and Wanivenhaus [21] presented a short-term follow-up after the open Kramer technique. They noted a 12% pin tract infection rate with the percutaneous wire fixation. Patients missed an average of 10 weeks of work.

Wilson, certainly influenced by the Hohmann osteotomy, presented an oblique distal metatarsal osteotomy in 1963 that remains in use in several parts of Europe (eg, England, Greece) [22]. This osteotomy is performed at the distal diaphyseal shaft of the first metatarsal. The osteotomy is angled 45° to the long axis of the metatarsal in the anteroposterior plane and 90° to the long axis of the osteotomy in the sagittal plane. Because of its geometry, the lateral displacement automatically shortens the first metatarsal. The osteotomy also provides no inherent stability. Because shortening of the first metatarsal incurs the risk of metatarsalgia, this osteotomy is not recommended. Schemitsch and Horne [23] presented a follow-up study of the Wilson osteotomy 5 years after surgery. The likelihood of second metatarsal metatarsalgia as in the case of short first metatarsals, was 50% and greater.

In 1920, Roux [24] presented a step cut osteotomy of the distal metatarsal. In 1931, Peabody [14] described outstanding 100% patient satisfaction, no recurrence, and no complications. Influenced by these results, this technique was popularized later by Mitchell et al [7], in 1958. The osteotomy cuts are perpendicular to the long axis of the metatarsal shaft. After performing the step cut osteotomy, which causes shortening of the first metatarsal, the distal fragment is translated laterally. Since the first descriptions, many modifications—including the removal of a larger plantar base, change of the inclination of the spike, and various fixation methods—have been proposed. Despite the modifications, shortening and dorsiflexion that lead to recurrence make the Mitchell osteotomy a technically demanding procedure [25].

In 1983, Merkel et al [26] presented a follow-up study of the Mitchell osteotomy. Only 59% of the patients was available for follow-up. Despite the overall satisfaction of 86%, the shortening was more than 5 mm in 39 of 56 patients. Generally, the osteotomy is inherently unstable [27] and most investigators advocate cast immobilization for 4 to 6 weeks [25,28].

The chevron osteotomy has become accepted widely for the correction of mild and moderate hallux valgus deformities. In the initial reports by Austin and Leventen [29] and Miller and Croce [30], no fixation was mentioned. They suggested that the shape of the osteotomy and impaction of the cancellous capital fragment upon the shaft of the first metatarsal provided sufficient stability to forego fixation.

Generally, the procedure is performed under peripheral nerve blockade with or without Esmarch tourniquet. A midside incision is made over the first MTP joint from midshaft of the proximal phalanx to approximately midshaft of the metatarsal. An inverted L or lenticular medial capsulotomy is used to expose the medial eminence (Fig. 1). The medial eminence is excised with a power saw. At this point, the V-osteotomy is planned and performed with care taken to ensure that each cut is made precisely to give stability, which is the essence of the procedure. A Kirschner wire is drilled medial to lateral through the first metatarsal head, aiming at the head of the fourth metatarsal and inclined 20° plantarly (Fig. 2). Two cuts are made with an oscillating power saw, such that they form an angle of 60° proximal to the drill hole. After the capital fragment is freely mobile, it is

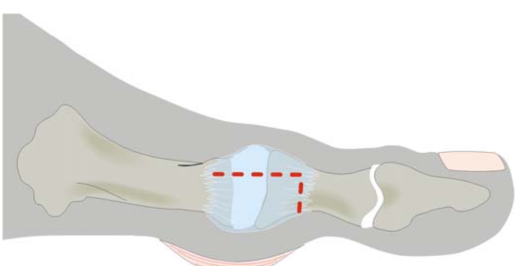

Fig. 1. Inverted L-type medial capsulotomy.

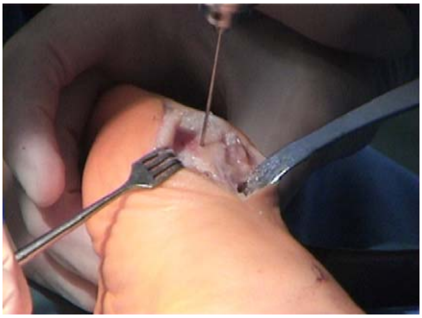

Fig. 2. Guide wire for the chevron osteotomy. 20° plantar inclination, aimed at the head of the fourth metatarsal.

transposed laterally (Fig. 3). When the joint surfaces are in correct alignment and the metatarsal head is in place, the capital fragment is impacted firmly onto the metatarsal shaft. The remaining medial "step defect" is removed. The medial capsule is closed by excising a triangle. Postoperatively, immediate weight bearing is allowed in a postoperative bunion shoe. Patients must wear this shoe for 6 weeks.

At the Orthopaedic Hospital Gersthof, we performed the original technique from 1991 to 1992 [31]. Comparing the 2-year and 5-year follow-ups, 43 patients (57 feet) were available for all three assessment periods—preoperative, 2-year and 5-year follow-ups [32]. Between 2 and 5 years of follow-up, there was only a minimal change in overall patient satisfaction (23 very satisfied at 2 years and

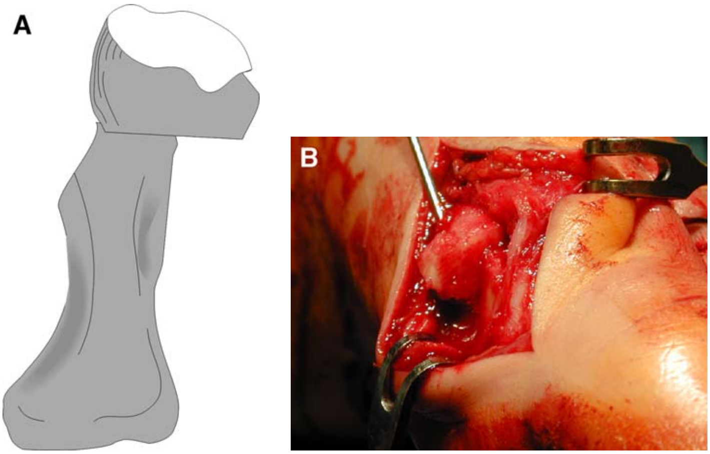

Fig. 3. Lateral transposition of the metatarsal head. (*A*) Drawing. (*B*) Intraoperative photograph.

24 very satisfied at 5 years) and the average hallux–MTP–interphalangeal scale score (91 points each). Range of motion of the first MTP joint decreased from 72° preoperatively to 61° at the 2-year follow-up; it was maintained at 62° at the 5-year follow-up Radiographic evaluation revealed a preoperative average hallux valgus angle of 29° (range, 16° to 50°) and a preoperative average intermetatarsal

Fig. 4. Chevron osteotomy in a 32-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 3, intermetatarsal angle 14°, hallux valgus angle 32°. (*B*) 2-year follow-up. (*C*) 5-year follow-up.

angle of 13° (range, 10° to 20°). At the 2-year follow-up, the hallux valgus and intermetatarsal angles averaged 15° (range, 0° to 40°) and 8° (range, 0° to 20°), respectively. At the 5-year follow-up, the hallux valgus and intermetatarsal angles averaged 16° (range, 0° to 40°) and 9° (range, 2° to 20°), respectively. An increase of MTP joint arthrosis was noted in 8 feet at the 2-year follow-up and in 11 feet between the 2- and 5-year follow-ups (Fig. 4).

In light of publications by Kitaoka et al [33] and Mann and Pfeiffinger [34] in 1991, a more radical lateral soft tissue procedure was added to the original procedure. Starting with an incision on the dorsal aspect of the foot in the first intermetatarsal space, a lateral soft tissue release was added to the chevron osteotomy. A longitudinal incision is made in the lateral joint capsule, just superior to the lateral sesamoid; the metatarsosesamoidal ligament is incised. The adductor tendon is identified and carefully dissected from the lateral capsule and then released from its insertion into the base of the proximal phalanx. The transverse metatarsal ligament is stretched and carefully incised to release the tethering effect on the sesamoid complex. The lateral capsulotomy is perforated at the joint line and the toe is forced manually into 20° varus position. Sutures through the adductor tendon and the lateral aspect of the first metatarsal lift the insertion of the adductor muscle; two stabilizing sutures are placed.

When comparing the results of this series with a series of patients who was operated on according to the original Austin technique [31], a much better correction of the hallux valgus angle, intermetatarsal angle, and, most importantly, the sesamoid position, were observed (Fig. 5) [35]. Earlier reports expressed concern about increased avascular necrosis (AVN) if a lateral release is performed

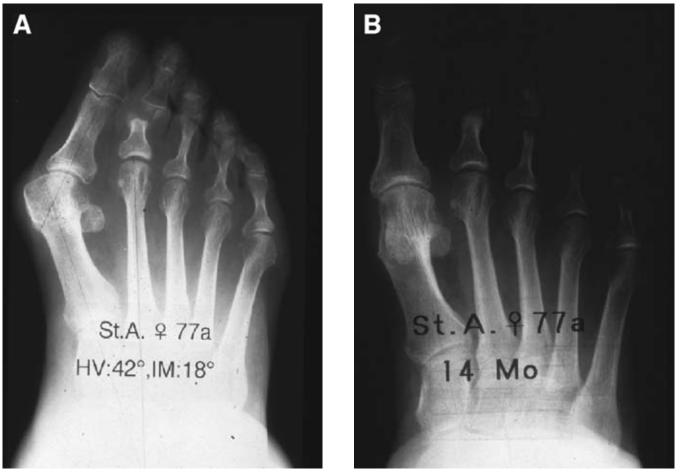

Fig. 5. Chevron osteotomy with lateral soft tissue release in a 77-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 3, intermetatarsal angle 18°, hallux valgus angle 42°. (*B*) 14-month follow-up.

in addition to a chevron osteotomy [36–38]. Jahss, Mann, and Kenzora suggested that AVN frequently accompanies lateral soft tissue release, with an incidence of up to 40% [36–38]. Analysis of Meier and Kenzora's [38] results, however, reveals a small percentage of patient follow-up and small groups of patients. Jones et al [39] investigated the blood supply to the metatarsal head. Using a modified Spalteholz technique in cadaveric specimens, they found an extensive network of extraosseous vasculature to the metatarsal head proximal and distal to the site of the osteotomy. Both of these vascular networks were preserved when the osteotomy was done properly. Neither Trnka et al [35], Pochatko et al [40], Thomas et al [41], nor Peterson et al [42] found an increased incidence of AVN of the metatarsal head.

One concern was the loss of correction by performing the chevron osteotomy without fixation. With the addition of a lateral soft tissue release, this concern gained importance. Jahss et al [43] noted a 12.5% loss of correction. Hattrup and Johnson [44] noted displacement in 4 of 225 chevron osteotomies. Multiple variations of chevron fixations have been described [45–56].

At the Orthopaedic Hospital Gersthof, we performed a prospective study of the chevron osteotomy with lateral soft tissue release and Kirschner wire fixation on 45 patients (55 feet). After an average follow-up of 34 months, there was no case of metatarsal head displacement or loss of correction [57]. The postoperative regimen included a postoperative bunion shoe for 6 weeks (Fig. 6).

Bettenhausen and Cragel [58], Goforth et al [46], and Klein et al [47] used screw fixation and limited the period of bunion shoe use to between 2 and 4 weeks. Starting in 1999, we used screw fixation using a oblique from medial to lateral 2.7-mm cortical screw (New Deal SA, Vienne, France) in patients who had good bone stock and a 1.6-mm Kirschner wire in elderly patients (>70 years of age) in patients who had poor bone stock (Fig. 7).

Fig. 6. Chevron osteotomy with lateral soft tissue release and pin fixation in a 49-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 2, intermetatarsal angle 13°, hallux valgus angle 30°. (*B*) 6-week follow-up.

Fig. 7. Chevron osteotomy with lateral soft tissue release and BOLD screw in a 63-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 2, intermetatarsal angle 15°, hallux valgus angle 34°. (*B*) 6-week follow-up.

According to papers by Harper [59] and Sarrafian [60], lateral displacement is limited to up to 50% of metatarsal width. Using our modified technique, we were able to extend the indication up to 75% of the metatarsal width (Fig. 8).

Midshaft osteotomy

The scarf osteotomy has gained popularity with the presentations of Weil [62], and especially, Barouk [61]. The word "scarf" is an architectural and carpentry term that is defined as "joint made by notching, grooving, or otherwise cutting the ends of two pieces and fastening together so that they lap over and join firmly onto one continuous piece" [62]. Various modifications of the scarf osteotomy have been described, including the short scarf [63], the long scarf [61,64,65], and the inverted scarf [53,66].

The scarf osteotomy—a midshaft osteotomy—should be more stable than other proximal metatarsal osteotomies, as shown by Trnka et al [67]. Mechanical testing of the classic scarf osteotomy failed to show improved stability over other osteotomies, such as the Mau and the proximal closing wedge, however. Barouk's modifications should decrease the rate of proximal metatarsal fractures [64]. In 2000, Weil [62] presented his results of 889 of 2120 patients who were operated on from 1984 to 1998. Although at a follow-up rate of only 42%, the results are not 100% reliable but the preoperative intermetatarsal angle was corrected from 15° to 9.8°. In 2002, Kristen et al [65] reported a retrospective study of 89 patients (11 feet) with a mean follow-up of 36 months (range, 24 to 48 months). The preoperative intermetatarsal angle was corrected from 14.5° to 7.9°. Postoperative complications included two cases of superficial wound infection and one case of traumatic dislocation of the osteosynthesis.

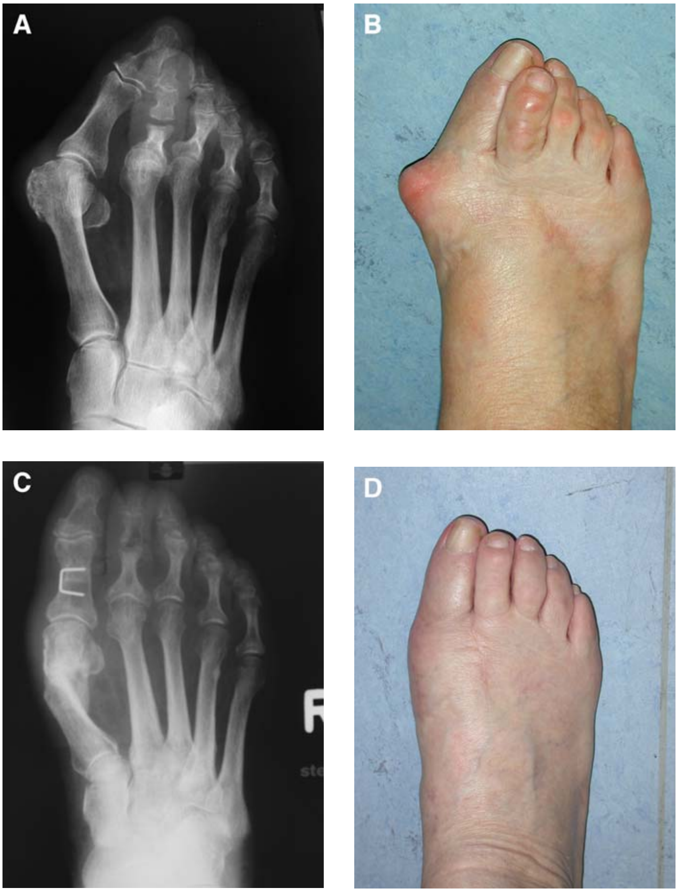

Fig. 8. Chevron osteotomy with lateral soft tissue release and pin fixation and Akin osteotomy in a 82-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 3, intermetatarsal angle 15°, hallux valgus angle 48°. (*B*) Preoperative photograph. 1-year follow-up radiograph (*C*) and photograph (*D*).

There is still controversy about up to what level of deformity a scarf osteotomy is indicated. The author's personal opinion is that the chevron osteotomy with the authors' modifications (lateral soft tissue release) has similar indications as the scarf osteotomy, but may be less demanding technically.

Proximal metatarsal osteotomies

From a mechanical standpoint, a proximal metatarsal osteotomy can achieve a greater degree of correction, and therefore, is recommended for more severe hallux valgus deformities. Various techniques have been described over the last century. Early reports date back to Loison in 1901 [9] and Balacescu in 1903 [10] who used a proximal closing wedge osteotomy. Opening wedge osteotomies were presented by Trethowan in 1923 [68] and Trott in 1972 [12].

Wedges have the advantage of addressing the deformity on one plane at or near the deformity [69]. A closing wedge osteotomy always is combined with a lateral soft tissue release. The osteotomy is performed with a microsaggital saw blade from the lateral side, 10 mm distal to the metatarsocuneiform. By preserving the medial cortex, a biplanar wedge with approximately 3-mm to 5-mm bases, laterally and plantarly, is removed and the osteotomy is closed (Fig. 9). Screw fixations are the most popular, but multiple Kirschner wire fixations were presented. Clinical studies confirmed the inherent instability and the high incidence of dorsal elevation and subsequent metatarsalgia. Trnka et al [70] presented the study with the longest follow-up (10 to 22 years). Of the 81 feet, patients rated outcome as excellent or good in 89% and cosmesis as excellent or good in 83%. Seventy-four feet (91%) were pain free at the final follow-up. Radiographically at final follow-up, hallux valgus and intermetatarsal angles averaged 18.6° (range, 0 to 40°) and 7.1° (range, 0 to 22°), respectively (Fig. 10). Excellent correction of sesamoid position was achieved; the average shortening was 5 mm. Wanivenhaus and Felder-Busztin [71] noted a 60% incidence of dorsal displacement.

The opening wedge is performed at the same level of the metatarsal bone; however, the osteotomy is performed from the medial side to preserve the lateral cortex. The opening wedge added the advantage of no shortening of the metatarsal, even some lengthening. The disadvantages are the question of donor site and the fixation. Originally, a fragment of the pseudoexostosis was used to fill the gap; however, the quality of this fragment is not sufficient, and, if the

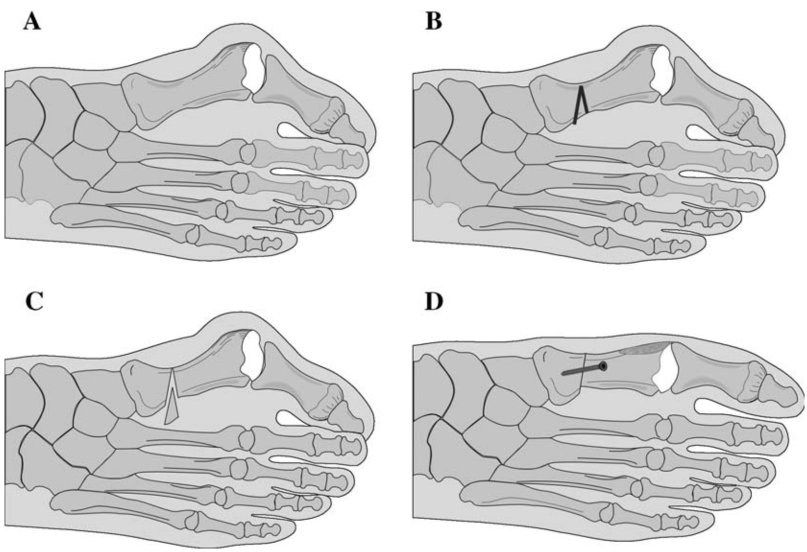

Fig. 9. (*A–D*) Closing wedge osteotomy.

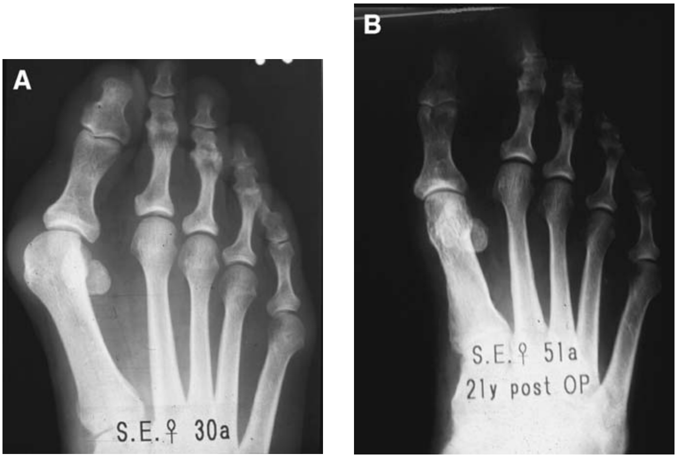

Fig. 10. Closing wedge osteotomy in a 30-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 3, intermetatarsal angle 19°, hallux valgus angle 40°. (*B*) 21-year follow-up.

resected fragment is thicker, there is a potential risk of joint incongruency and hallux varus. Other options are allografts or autografts from the calcaneus. Stable fixation without prolonged cast immobilization has not been presented.

The proximal crescentic osteotomy is one of the most popular proximal osteotomies. Mann and colleagues [13,72,73] popularized this procedure over the last decades. Always in combination with a lateral soft tissue release, either a third skin incision is made at the longitudinal dorsomedial skin incision at the osteotomy site or the incision over the medial eminence is extended proximally to the metatarsocuneiform joint in a slightly curved manner. Using a oscillating Hall Zimmer saw with curved blade, the osteotomy is cut halfway between the planes perpendicular to the metatarsal shaft and perpendicular to the ground, 1.5 cm to 2 cm distal to the tarsometatarsal joint.. After manual displacement of the fragments, the obtained correction is checked and the osteotomy is fixed with a 4.0-mm cancellous screw. Additional Kirschner wires or crossed Kirschner wires as the only modes of fixation are used only when screw placement is unstable or impossible (Fig. 11).

In 1992, Mann et al [74] published a retrospective review of 75 patients (109 feet) who underwent proximal crescentic osteotomy and distal soft tissue realignment. At a mean follow-up of 34 months, all osteotomies had healed; average hallux valgus angle correction was 21° (range, 9° to 31°) and average intermetatarsal angle correction was 8° (range, 6° to 14°). Patient satisfaction was high (93%) and shortening of metatarsals averaged 2 mm. In 28% of patients, elevation of the first metatarsal without clinical significance was noted. With an average preoperative intermetatarsal angle of 13.5° (range, 8° to 20°), most of these deformities were moderate. In 2000, Zettl et al [75] presented a retrospective study of 96 patients (117 feet) who had an average preoperative intermetatarsal angle of 17.8° (range, 10° to 26°) (Fig. 12). Dorsal malalignment was seen in

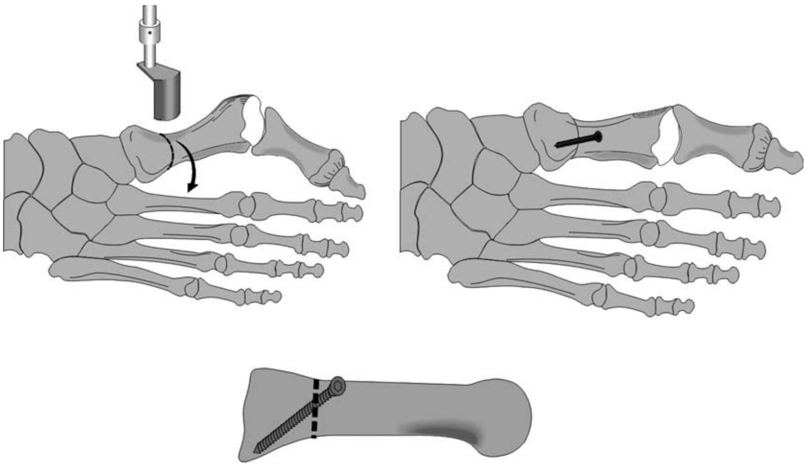

Fig. 11. The proximal crescentic metatarsal osteotomy.

95% of patients. These favorable results were confirmed in a long-term follow-up study by Dreeben and Mann [76]. After a mean period of 5.5 years, loss of correction averaged 1.4° for the intermetatarsal angle and 3.8° for the hallux valgus angle. Incidence of varus and recurrent valgus deformity had not increased from the initial follow-up study and patient satisfaction remained high (85%).

Recent reports by Sammarco et al [77–79], Easley et al [80], and Borton and Stephens [81] popularized the proximal chevron osteotomy for more severe deformities. This osteotomy is performed on the medial aspect of the first metatarsal, 15 mm distal to the metatarsocuneiform joint. The apex of the osteotomy is directed distally; a 0.045 Kirschner wire is inserted to mark the apex. The

Fig. 12. Proximal crescentic osteotomy in a 64-year-old woman. (*A*) Incongruent MTP joint, sesamoid position 2, intermetatarsal angle 17°, hallux valgus angle 30°. (*B*) 49-month follow-up.

microsagittal saw is used to complete the osteotomy. The distal fragment is shifted laterally and fixation is completed with a 3.5-mm cortical screw.

Sammarco et al [77] reported excellent correction, quick healing, ease of performance, and high patient satisfaction. Easley et al [80] noted a shorter healing time and avoidance of dorsiflexion, compared with the crescentic osteotomy, in a prospective study.

In a biomechanical study on 60 fresh frozen, human, lower extremity cadaveric specimens (10 for each osteotomy), the sagittal stability of six different metatarsal shaft osteotomies—the proximal crescentic, proximal Chevron osteotomy, Mau, Scarf, Ludloff osteotomy, and biplanar closing wedge osteotomy with plantar plate fixation—was investigated [67]. The various osteotomies were performed according to the originally described techniques, the specimens were potted within a PVC tube with polyester resin, and clamped to a MTS Mini Bionex load frame with the metatarsal in 15° of inclination. Cantilever-bend load was applied at a rate of 5 mm/min until failure. Failure was defined as bony fracture, screw pull out, or a fracture gap that was greater than 2 mm as measured by the extensometer. Statistical analysis revealed significant differences ($P = .05$) between the Ludloff, Mau, scarf, and biplanar closing wedge osteotomies compared with the chevron and crescentic osteotomies. There were no statistically significant differences between the Mau, biplanar closing wedge, scarf, and Ludloff osteotomies.

Using the same osteotomies, Nyska et al [82] performed a saw bone three-dimensional digitizer study to evaluate the three-dimensional geometric changes in the relative positions of the proximal and distal segments in each osteotomy (eg, lateral displacement, angular rotation, elevation, shortening). Scarf and proximal chevron osteotomies, being displacement osteotomies, provided less angular correction. The Ludloff osteotomy provided lateral and angular correction similar to those of the crescentic and closing wedge osteotomies with less elevation and shortening. Taking the results of these two papers in account, the Ludloff osteotomy seems to be the most favorable osteotomy for correction of more severe hallux valgus deformity.

In 1918, Ludloff [11] described an oblique osteotomy of the first metatarsal from dorso-proximal to distal-plantar. He originally shortened the metatarsal without internal fixation. The Ludloff osteotomy was abandoned for many years because of its lack of stable fixation. In 1983, Cisar et al [83] presented the Ludloff osteotomy with internal fixation. They still performed the osteotomy first and then fixed it by two Schweizerische Arbeitsgemeinschaft für Osteosynthesefragen (AO) screws. Because of the unstable situation during the correction, shortening of the first metatarsal was likely. Mark Myerson, unaware of Cisar's German publication, also was fascinated by the geometry and the rotational correction of the osteotomy. He modified the old technique with a modern osteosynthesis and presented his first experience in 1997 at the joint meeting of the American Foot and Ankle Society and the Japanese Society for Surgery of the Foot in Hawaii [84].

The surgery starts with a dorsal incision over the first web space. The lateral joint capsule is incised longitudinally, just superior to the lateral sesamoid. The adductor tendon is identified and carefully dissected from the lateral joint capsule and the lateral sesamoid and is released from its insertion into the base of the proximal phalanx. The lateral capsule is perforated at the joint line and the great toe is forced manually into approximately a 20° varus position. One suture is placed through the adductor tendon and the lateral aspect of the first metatarsal and on the other side through the periosteum of the 2nd metatarsal to lift the insertion of the adductor muscle and to stabilize between metatarsal 1 and 2.

A second skin incision is made at the medial aspect of the first MTP joint. This incision is extended proximally in a slightly curved manner to the first metatarsocuneiform joint. The medial MTP joint capsule is opened with an inverted L-type incision. The joint is inspected for degenerative changes. The metatarsal shaft is now exposed and a Hohmann retractor is placed dorso-proximal and distal-plantar. The distal-plantar Hohmann retractor protects the plantar artery to the metatarsal head, whereas the dorso-proximal retractor protects the extensor hallucis longus tendon and the interosseous branch of the dorsal pedis artery. An oblique osteotomy is made at the first metatarsal from dorsal—at the level of the metatarsocuneiform joint—to distal and ending proximal to the sesamoid apparatus. The dorsal two thirds of the osteotomy is performed first. A guide-wire for the 3.0-mm cannulated Synthes (Oberdorf, Switzerland) screw is inserted at the proximal end of the dorsal fragment, perpendicular to the osteotomy. A 3.0-mm cortical screw is inserted without total closing of the osteotomy. The osteotomy is finished distally. Using a towel clip, the plantar fragment is pulled medially and the dorsal fragment is rotated laterally with the push of the thumb. After the desired correction is achieved, the dorsal screw is tightened and a BOLD screw (New Deal SA) is inserted from plantar to dorsal at the distal aspect of the osteotomy. The medial eminence is excised in line with the metatarsal shaft with care taken not to excise too much bone off the metatarsal head (Fig. 13).

Attention is now directed toward the medial capsule; a wedge of approximately 5 mm is removed from the short arm of the L-type capsular incision. While an assistant holds the great toe in a slightly overcorrected position, the medial joint capsule is repaired and the first web space sutures are tightened. After skin closure, the foot is wrapped in compression dressing which protects the soft tissue repair and holds the great toe in its corrected position. The osteotomy is checked by radiography. Depending on the intraoperative stability and tolerance, the patient can walk without restriction in a postoperative shoe with a stiff sole or is placed in a walking cast. The dressing is changed after 2 days and then on a weekly basis. Full weight bearing without the postoperative shoe is allowed after 6 weeks.

Our first preliminary results of 75 patients with an average follow-up of 33 months revealed excellent correction of the hallux valgus and intermetatarsal angles. The mean correction of the hallux valgus angle was 26.5°, from 36° preoperatively to 14° at final follow-up. The intermetatarsal angle was corrected an average of 9°, from 17° preoperatively to 8° at final follow-up (Fig. 14). Thus, according to our deformity grading, 80% of cases showed normal values for the

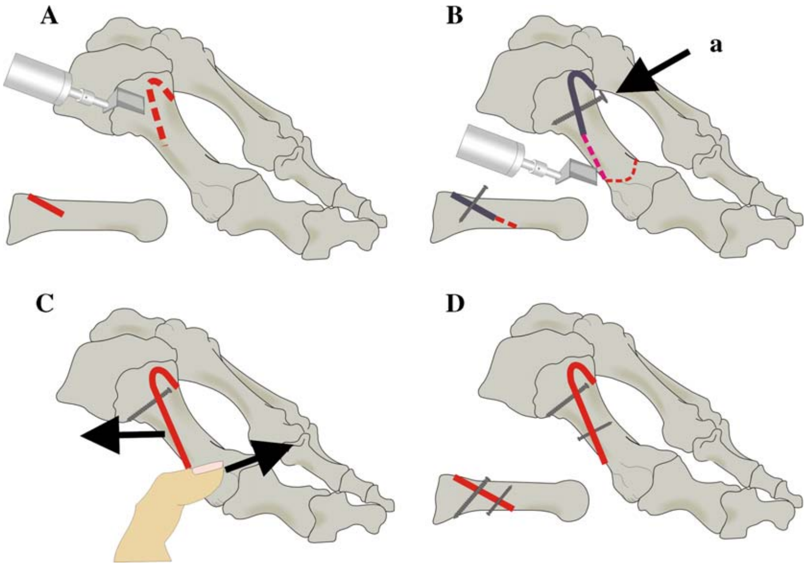

Fig. 13. (*A–D*) The Ludloff osteotomy.

hallux valgus and intermetatarsal angles or presented with a mild residual deformity after the procedure. Care should be taken in elderly patients. In 15 feet we found increased callus formation around the osteotomy site; 6 of those were considered to be a delayed bony healing. The average age of the patient who had increased callus formation was 67 years, whereas the average age of the other patients was 53 years. Radiographic analysis also revealed a more osteopenic bone situation preoperatively in the patients who had callus formation.

Fig. 14. Ludloff osteotomy in a 49-year-old man. (*A*) Incongruent MTP joint, sesamoid position 3, intermetatarsal angle 18°, hallux valgus angle 39°. (*B*) 2-year follow-up.

Summary

A variety of metatarsal osteotomies has been described since the first report by Gernet in 1836. Many of these osteotomies were abandoned throughout the years. Because one procedure is not capable of correcting all types of hallux valgus deformities, an algorithm, as a guideline, is preferable.

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