

Original Article

Results of Combined Proximal Crescentic Metatarsal Osteotomy and Modified Distal Soft Tissue Procedure in Severe Hallux Valgus

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ABSTRACT

Objective: To review subjective, objective, and complication results of surgery of combined proximal crescentic metatarsal osteotomy and modified distal soft tissue procedure in adult foot severe hallux valgus deformities

Design: Retrospective clinical study

Setting: Al-Jahra Hospital Orthopedic Department and Al-Razi Orthopedic Hospital

Methods: We retrospectively studied the results for thirty consecutive patients (38 feet), in whom a severe hallux valgus deformity with hallux valgus angle (HVA) > 40° and first / second inter-metatarsal angle (1/2 IMA) > 16° had been corrected surgically. The surgery included proximal crescentic osteotomy of the first metatarsal, lateral release of the distal soft tissues, excision of the medial eminence, plication of the medial part of the capsule of the 1st metatarso-phalangeal joint (1st MTP) and a modification of Z-plasty lengthening of the extensor hallucis longus (EHL) tendon. The patients were followed up for an average of twenty-eight months (range 17-47 months).

Results: The preoperative HVA averaged 48° and postoperative angle averaged 13°. The preoperative 1/2 IMA averaged 18° and postoperative angle averaged 7°.

Ninety-three percent of the patients were satisfied with the results of the procedure. They stated that, given the same circumstances, they would have the operation again. A clinical and radiological excellent to good correction was achieved in 95% of the feet (excellent in 79% and good in 16%) with an average American Orthopedic Foot and Ankle Society (AOFAS) hallux score of 92 out of 100 points.

Complication: included recurrence of gross hallux valgus deformity in two dissatisfied patients (2 feet, 6.6%) and mild under-correction of six feet in four patients (13%). However, the patients were satisfied with the relief of pain and the cosmetic appearance of their feet. Hypoesthesia along the medial aspect of the great toe occurred in two patients (2 feet, 6.6%). Pin track infection occurred in two patients (2 feet, 6.6%) and deep infection in one patient. All were cured after debridement and antibiotics.

Conclusion: According to the results of this report and other studies in the literature, proximal crescentic metatarsal osteotomy combined with distal lateral release, medial repair and lengthening of the EHL tendon is a reliable and successful surgery for treating severe hallux valgus deformity.

KEYWORDS: hallux valgus, metatarsal deformity, proximal crescentic osteotomy

INTRODUCTION

The deformity of hallux valgus is the lateral deviation of the great toe. It is associated with other pathological features which include: medial deviation of the first metatarsal (metatarsus primus varus) with increased inter-metatarsal angle (IMA) between the first and second metatarsals, prominent medial eminence, contracted soft-tissue structures on the lateral side of the great toe, lateral displacement of the sesamoids and contracture of the extensor and flexor tendons leading to lateral rotation of the metatarsal head and pronation of the hallux^[1-4]. A hallux valgus angle (HVA) > 40° and inter-metatarsal angle (1/2 IMA) > 16° are the radiological features defining severe hallux valgus.

Commonly, the severe hallux valgus is characterized by progressive subluxation and incongruity of the first metatarso-phalangeal joint with altered distal metatarsal articular angle (DMAA). The deformity is attributed to congenital hereditary metatarsus primus varus with 55-60% positive family history and to the acquired splayed foot secondary to weak intrinsic muscles with contribution from the effect of shoe wearing^[5,6].

More than 130 different surgical procedures have been described to treat this deformity^[5,8,9]. The main procedures to surgically treat severe hallux valgus include: proximal osteotomy to correct the first metatarsal deformity by opening a wedge, closing a wedge, crescentic and proximal chevron

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Sammarco osteotomies with distal soft-tissue release and medial plication. It also includes scarf, Mau and Ludloff ostotomies^[2,3,5,7,8]. The first tarsometatarsal arthrodesis is also an option in the surgical management of severe hallux valgus with hypermobile first ray or as salvage after failed other bunion repair surgeries^[7,9].

Post-surgical complications are always the concern of both patients and surgeons and include: recurrence of deformity, poor cosmetic appearance, under-correction, over-correction with hallux varus deformity, shortening of the first ray, and elevation of the first ray causing transfer lesion to second metatarsal head (transfer metatarsalgia)^[3,5,8,9].

In this report, we present the subjective, objective, radiological and complication results of surgical treatment of severe hallux valgus by proximal dome osteotomy with distal soft tissue release and medial plication. We added a modification of Z-plasty of the extensor hallucis longus (EHL) tendon through the dorso-medial incision to the distal soft tissue procedure^[11].

PATIENTS AND METHODS

Between May 1996 and April 2003, thirty consecutive patients with thirty-eight feet of severe hallux valgus were treated surgically in Al-Razi Orthopedic Hospital and Jahra General Hospital, Kuwait. The patients who were retrospectively interviewed, gave their informed consent before entering the trial and were examined clinically, radiologically and complicationwise as also for assessment of their satisfaction with the results of the surgery. The pre and post-operative clinical data were gathered according to guidelines recommended by the American Orthopedic Foot and Ankle Society AOFAS^[8]. The weight-bearing dorso-plantar and lateral feet radiograms were collected from the patient's medical records and compared with final follow-up evaluation.

Outcome:

The primary outcome of this study was the clinical and radiological correction of the severe hallux valgus deformity. The secondary outcome was the patient's satisfaction regarding the correction of the deformity.

Clinical assessment:

The series of patient in this study included thirty consecutive patients with thirty-eight feet, who had a severe degree of hallux valgus deformity. The deformity was unilateral in twenty-two patients (73%) and bilateral in eight patients (27%) with ratio 3:1. There were 25 female (83%) and five male patients (17%) with ratio 5:1. The average age was thirty-eight years and the range was 22-48 years.

The indication was pain and deformity in twenty-seven patients (90%) including the twenty-five females and only pain in the remaining three males (10%). Twenty patients (67%) suffered from problems with shoe fitting and desired operative correction. Pre and post-operative assessment was made according to the protocol of the American Orthopedic Foot and Ankle Society (AOFAS). This system provides a score ranging from Zero to 100 points, which takes into consideration both subjective and objective elements such as pain (maximum score = 40 points), functional capacity (maximum score = 45 points), and hallux alignment (maximum score = 15 points). Other factors that were evaluated in the clinical assessment were any limitation of daily and/or sports or recreational activity, the type of shoes that the patient could wear, the stability of the 1st MTP and interphalangeal joints, and the presence of calluses. The patient's satisfaction with the outcome (satisfied or unsatisfied) was also elicited. The active and passive range of motion of the first metatarsophalangeal joint was measured with a goniometer (with the patient not bearing weight, with measurement of angle between the proximal segment of the great toe and the plantar surface of the foot). The advantage of using the plantar surface of the foot as the point of reference is that Zero degree represents the functionally neutral position of the toe. Active and passive dorsiflexion and plantar flexion were recorded from this neutral axis of reference. Rotational mal-alignment (pronation-supination deformity) of the great toe was graded: no rotation was considered to be grade Zero; rotation of less than 25 degrees, grade 1; rotation of 25 to 45 degrees, grade 2; and rotation more than 45 degrees, grade 3. The assessment was made with the patient standing. The pronation of the hallux was documented in the patients' medical records in 24 patients (80%), 27 feet (71%). The hypermobility of the metatarsocuneiform (MTC) joint was not documented in any patient's record in this series.

Radiological assessment:

The radiological assessment of patients' pre-operative radiographs included: the HVA, the 1/2 IMA, the DMAA, the subluxation of the first metatarso-phalangeal joint (1st MTP), the position of the sesamoids, the lengths of the first and second metatarsals (so that any post-operative shortening could be measured accurately), and the osteoarthritic changes of the metatarso-phalangeal joints.

The hallux valgus angle (HVA) is subtended by lines along the long axis of the first metatarsal and the proximal phalanx. Normally, the HVA is < 15°. The inter-metatarsal angle 1/2 IMA is subtended by lines along the longitudinal axis of the first and

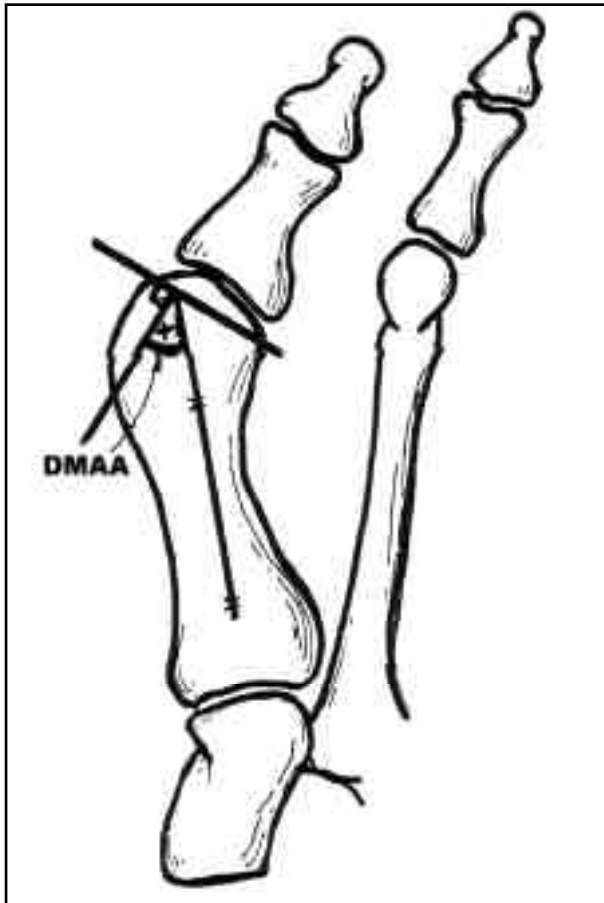


Fig. 1: Measurement of the DMAA (it is the angle subtended by a line drawn perpendicular to the metatarsal articular surface and the longitudinal axis of the first metatarsal).

second metatarsals. Normally the $1/2$ IMA is $< 9^\circ$. The distal metatarsal articular angle (DMAA) describes the lateral scope of the articular surface in relation to the long axis of the first MT as shown in Fig. 1. Normally, the DMAA is $< 100^\circ$. The position of the tibial sesamoid on the antero-posterior (dorsi-plantar) radiographs was described as medial, lateral, or central in relation to a line drawn along the centre of the longitudinal axis of the first metatarsal. The sesamoid was considered to be medial, if 75 per cent of it was located medial to the central line and as lateral, if 75 per cent of it was located lateral to the central line. Otherwise, the sesamoid was considered to be located centrally. Normally, on the dorso-plantar view the metatarsal head overlies both the tibial and fibular sesamoids and the tibial one is medial to the longitudinal axis of the first metatarsal.

The average pre-operative HVA was 48° (range = 43° - 54°) and the average of pre-operative $1/2$ IMA was 18° (range = 16° - 22°). The MTP joint was subluxated pre-operatively in all patients (100%), but DMAA was normal in 13 feet (33%). The average of the abnormal DMAA was 113° (range = 104° - 117°). The tibial sesamoid was located

Table 1: Pre-operative clinical assessment

Parameter	Result n (%)
Patient's complaints	
Pain only	03 (10)
Pain and deformity	27 (90)
Wearing shoes problems	20 (67)
Objective findings	
Severe hallux valgus	38 (100)
Pronation of the hallux	24 (63)
Hypermobility of MTC joint	None

centrally in 20 feet (52.5%) and laterally in 18 feet (47.5%). Osteoarthritis of the 1st MTP was not observed in any of the preoperative radiographs. A summary of the pre-operative clinical assessment is shown in Table 1.

Statistical Analysis :

Due to the small sample size of thirty patients (thirty-eight feet) of hallux valgus in the study, Student - t test was chosen to estimate the significance of the difference in pre-operative and post-operative HVA and $1/2$ IMA values. Because the outcome of the surgery was uncertain in reducing the HVA and $1/2$ IMA, an independent parametric two- sided (tailed) test was used. This particular kind of statistical tests allows larger variance and have longer tails than the standard normal distribution, which fits the data and the nature of this study and being parametric makes it more powerful in detecting significance. The over-all level of alpha significance (p-value) in the study was 0.05 and there is a 26 percent chance of at least one spuriously significant difference over-all ($p = 1 - [1 - 0.05]$).

Surgical Technique:

A prophylactic antibiotic (1 gm) from the third generation of cephalosporins is routinely injected IV with induction of anesthesia and before application of the tourniquet. The distal soft tissue procedure to correct a hallux valgus deformity consists of several steps and was performed through two incisions. The first is made dorsally in the line of the first web space of the foot to release the adductor hallucis, and to release tendon from the base of the proximal phalanx and the fibular sesamoid, the transverse inter-metatarsal ligament and the lateral capsule of the first metatarso-phalangeal joint. The second incision is made midline over the medial eminence to remove the medial eminence and perform a capsulorrhaphy. The proximal osteotomy is done through a four-centimeter dorsal and longitudinal third incision that starts over the base of the first metatarsal and ends just proximal to the metatarso-

Table 2: Post-operative clinical results

Parameter	Result n (%)
Subjective	
Pain relief	27 (90)
Comfortable shoe fitting	18 (60)
Satisfaction with surgery	28 (93)
Objective	
Excellent correction	30 (80)
Good correction	6 (15.7)
Recurrence	2 (5.3)
AOFAS hallux score	Average score 92 points, range (81-97 points)

Table 4: Pre-operative versus post-operative radiological findings

Parameter	Pre-op assessment M (range)	Post-op results M (range)	Level of significance
HVA	48° (43°-54°)	13° (8° - 22°)	p 0.05 significant
1/2 IMA	18° (16°-22°)	7° (5° -12°)	p 0.05 significant
DMAA	<100° in 13 feet (34%)	<100° in 34 feet (90%)	p 0.05 significant
Tibial sesamoid	Medial in 0 feet	Medial in 28 feet (74%)	p < 0.01 highly significant
Shortening of 1st MTB	--- NA	6.3% (1.7%-11%)	Not significant
Dorsal angulation	--- NA	15 feet (39%)	p 0.05 significant
O-A1st MTP	--- NA	One foot (2%)	Not significant

M = mean NA= not available

cuneiform joint. The metatarsal osteotomy is begun one to one and half centimeter distal to the metatarso-cuneiform joint with the use of an oscillating saw that has a curvilinear blade with the concavity of the cut directed proximally (dome or crescentic shaped osteotomy). The osteotomy is displaced by retraction and pushing of the proximal fragment medially and moving the distal portion laterally with supination and rotation around the proximal fragment. This usually results in a lateral displacement of the distal portion by about 3 - 5 mm to reduce the 1/2 IMA and correct the metatarsus primus varus deformity of the 1st metatarsal. The supination of the distal portion of the metatarsal osteotomy and the great toe reduces the sesamoids beneath the metatarsal head correcting the great toe pronation, which mostly accompanies severe hallux valgus. The site of osteotomy is stabilized by either two K-wires (in thirty feet) or by 4 mm cancellous screw (in eight feet). The medial part of the joint capsule is repaired with the great toe held in neutral dorsi-flexion plantar-flexion position with slight varus over correction. Through the second medial incision, the extensor hallucis longus tendon is accessed and lengthened by Z-plasty according to its tension after the correction of hallux valgus deformity by

Table 3: Pre-operative versus post-operative clinical assessment

Parameter	Pre-operative assessment n (%)	Post-operative results n (%)	Level of significance
Pain	30 (100)	03 (10) Mild pain	p 0.05 significant
Shoe fitting problems	20 (67)	2 (7)	p 0.05 significant
Hallux valgus deformity	38 feet (100)	2 (5.3) Recurrence	Highly significant p < 0.01

Table 5: Post-operative complications

Complication	n (%)	Feet (%)
Medial hypothesis of the hallux	2 (6.6)	2 (5.3)
Pin track infection	2 (6.6)	2 (5.3)
Deep infection	1	1
Mild under- correction	4 (13)	6 (15.7)
Recurrence of gross hallux valgus	2 (6.6)	2 (5.3)
Osteoarthritis 1st MTP	1	1

proximal osteotomy and the distal capsulorrhaphy and lateral release. Post-operatively, the hallux is protected in the corrected position by using P.O.P slipper cast, which encases the hallux and foot without immobilizing the ankle allowing its free movements. The patient is allowed to walk from the second post-operative day in the non-weight bearing mode using crutches.

Follow-up:

The patients were followed-up for an average of twenty-eight months (range 17- 47 months). During the follow-up the cast and the K-wires were removed 4-6 weeks post-operatively and the patient started on a physiotherapy program for active and passive dorsi-flexion and plantar flexion exercises of the hallux and other toes. The patient was allowed to bear weight partially and then fully aided by crutches eight weeks post-operatively. After 10-12 weeks post-operatively, the patients discarded crutches and returned to normal activities.

RESULTS

The results were categorized into subjective, objective, radiological and complications.

A- Subjective results:

Out of all 30 patients (100%) who complained of pain in their feet located primarily around the 1st MP joint pre-operatively, only three had persistent mild discomfort post-operatively (10%). Out of 20 patients (67%) with shoe-fitting problems pre-operatively, 18 (90%) could be fitted with the same shoe more comfortably post-operatively and 14 (70%) of these patients could even be fitted with a



Fig. 2a



Fig. 2b



Fig. 2c

Fig. 2: Severe hallux valgus deformity with severe subluxation of the first metatarsophalangeal joint in the right foot of a 32 year old male patient



Fig. 2d:

a. Pre-operative standing antero-posterior radiograph; b. Post-operative standing antero-posterior radiograph; c. Final follow up radiograph after four years; d. Photograph of the right foot showing satisfactory correction of the deformity.

narrower shoe. The status of two patients (10%) remained unchanged with regard to the fitting of shoes. Twenty-eight patients (93%) were satisfied with the results of surgery and the shape of their foot or feet. Two patients (6.6%) were dissatisfied with the operative result due to recurrence of

average passive dorsi-flexion was 60 degrees with a range of 30°-70°. The post-operative active plantar flexion averaged 26 degrees with a range of 10-45 degrees and the passive average was 35 degrees with a range of 15 - 50 degrees. There was residual hallux pronation in three feet (18%) in three patients (10%). The post-operative results are shown in Table 2. The post-operative clinical assessment has been further elaborated by using the American Orthopedic Foot and Ankle Society (AOFAS) hallux score^[5,7,9]. The average score among thirty patients in this study was 92 out of 100 points with a range of 81- 97 points. A comparison of the pre-operative assessment and post-operative results is shown in Table 3.

C- Radiological Results:

The osteotomy site was united in all feet, irrespective of the method of fixation. The HVA was corrected an average of 35 degrees after the procedure. The post-operative latest follow-up average HVA was 13 degrees (range = 8 - 22 degrees) and it was less than 10° in 19 patients (50%) with 26 feet (68.4%). 1/2 IMA was corrected to an average of 11 degrees. The angle averaged 7° (range 5°-12°) as shown in (Fig. 2: a, b, c) & (Fig. 3: a, b, c). Post-operatively, the tibial sesamoid was positioned medially in 28 feet (74%), centrally in seven feet (18.5%) and laterally in the remaining three feet (7.5%). In the latest postoperative weight bearing antero-posterior foot radiograph, the DMAA was corrected to <100° in 34 feet (90%) and > 100° in four patients and the averaged DMAA

the hallux valgus deformity to its pre-operative magnitude and persistence of pain.

B- Objective results:

The hallux valgus deformity was corrected to a clinically neutral hallux with regard to the valgus-varus deformity in 30 feet (80%). Six feet (15.7%) had residual mild hallux valgus. Two feet (5.3%) in two patients had recurrence of gross hallux valgus post-operatively. Active dorsi-flexion of the first MP joint averaged 50° with a range of 25°- 65°. The



Fig. 3a



Fig. 3b



Fig. 3c



Fig. 3d

Fig. 3: Severe hallux valgus deformity with severe subluxation of 1st MTP joint in the left foot of a 25 years-old female patient.

a. Preoperative standing antero-posterior radiograph; b. Postoperative standing antero-posterior radiograph; c. Final follow up radiograph after three years; d. Photograph of the left foot-showing correction of the deformity

was 9° . The subluxation of 1st MP joint was corrected in 35 feet (95%) while it recurred in two feet (5%). The length of 1st and 2nd metatarsals was measured with weight bearing radiographs to determine metatarsal

shortening after surgery. The method of measuring first metatarsal shortening is shown in Fig. 4. The percentage of shortening of the first metatarsal averaged 6.3% (range = 1.7% - 11%) after the osteotomy.

Post-osteotomy, the first metatarsal dorsal angulation (elevation) malunion was noticed in 15 feet in 12 patients (40%). Dorsal angulation occurred in four feet where the osteotomy was fixed by 4.0 mm cancellous screw and in two of them the angulation was noticed in the immediate post-operative radiographs and in the other two, the angulation was noticed during the late follow-up (50% of the osteotomies fixed by screws). Dorsal angulation occurred in 11 feet where the osteotomy was fixed by K-wire (36.6% of the feet fixed by K-

wires), four of them noticed in immediate post-operative radiographs and the rest were observed late in the follow-up. The osteoarthritic changes in the 1st MTP joint noted, in latest follow-up in one foot with narrowing of the joint space and subchondral sclerosis. A comparison of pre-operative and post-operative radiological assessment is shown in Table 4.

Complications:

Hypoesthesia on the medial aspect of the hallux due to digital nerve injury was noted in two patients (6.6%). In two patients (6.6%) where the metatarsal osteotomy was fixed by K-wires, pin track infection occurred which was cured by local debridement and antibiotics. Deep infection occurred in one patient (3.3%), which was treated by wound debridement under general anesthesia and antibiotics and this subsided with wound healing three weeks after the debridement surgery. No painful transfer metatarsalgia with or without plantar keratosis under the head of second metatarsal developed after surgery in any patient.

Recurrence of gross deformity occurred in two feet (5.3%) in two patients (6.6%). Six feet (15.7%) in four patients (13%) had mild residual deformity of hallux valgus but the patients were satisfied with the cure of pain and the cosmetic appearance of their feet. Over correction with hallux varus deformity was not noticed in any of the patients in this series (Table 5).

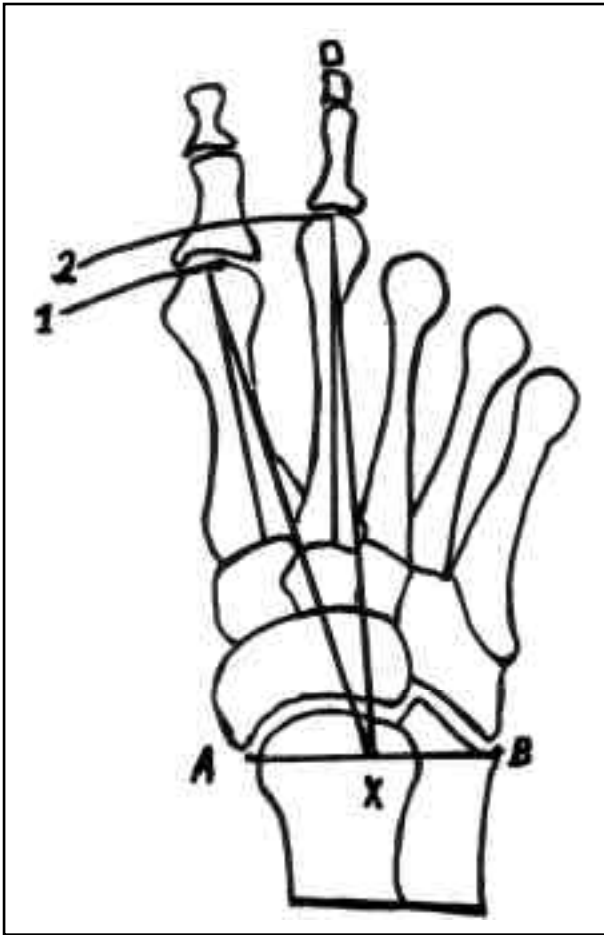


Fig. 4: Measuring first metatarsal shortening (X is the midpoint of AB. The percentage of shortening of first metatarsal is then expressed as $X1/X2$ pre-operative divided by $X1/X2$ at review x 100).

DISCUSSION

Selection of the operative technique for correction of the bony deformities in hallux valgus patients is mainly based on the first to second intermetatarsal angle ($1/2$ IMA). Severe deformity where the $1/2$ IMA is $> 16^\circ$ can be corrected using proximal metatarsal osteotomies (proximal chevron, crescentic, opening, and closing wedge osteotomy) with distal soft tissue procedures^[2,4,9]. Arthrodesis is also advocated in severe painful hallux valgus^[5]. Reported series show that success rates for the proximal osteotomies are comparable, achieving satisfactory results in the zone of 80 to 90%^[7,9]. The studies have shown, as well that those proximal osteotomies may lead to substantial complications, including first metatarsal elevation, metatarsal shortening and transfer metatarsalgia due to altered forefoot loading^[3,11,12,13].

Regardless of adequate fixation of the first metatarsal proximal osteotomy, dorsal angulation has been reported to occur in the range of 28 - 82% patients undergoing the procedures. Although this angulation may occur as an intra-operative technical failure, post-operative dorsi-flexion can

similarly occur as a result of early weight bearing on a relatively unstable osteotomy. One of the big advantages of proximal osteotomies is that it achieves an actual instead of relative correction of the intermetatarsal angle^[3,5,7,11].

The crescentic basilar osteotomy, in particular, has the problems of sagittal instability and post-operative first metatarsal dorsal angulation, most likely due to poor osteotomy placement and difficulty in fixation. But the technique still provides a powerful tool to correct wide intermetatarsal angles with minimal shortening. One could also adjust the procedure in order to obtain exact correction without additional wedging and facilitate triplanar correction by angling the osteotomy in various directions. The rate of first metatarsal dorsal angulation was 39% in this study distributed among the cases fixed by K-wires (36.6%) and osteotomies fixed by screws (50%) with a difference which does not reflect any statistical significance. However, none of the patients developed transfer metatarsalgia, most likely due to low incidence of first metatarsal minimal shortening (average of 6.3%). One of these complications aggravates the other in that if there is both shortening and dorsi-flexion, the problem of a transfer lesion is compounded. There are times when dorsi-flexion occurs with minimal shortening and no problem results^[15,17].

In 1982, Cedell and Astrom reported the results of a basal dome osteotomy and distal soft tissue procedure in forty-six feet. The results were excellent in 78% of the feet and good in 11%^[12,13]. In 1992, Mann reported the results of proximal Crescentic osteotomy with distal soft-tissue repair in seventy-five patients (109 feet). A majority (93%) of the patients were satisfied with the surgery^[18,19]. In our series, 93% patients were satisfied with the outcome of surgery. Excellent correction of the severe hallux valgus was achieved in 79% patients and good correction in 16% patients with average AOFAS hallux score of 92 points (range = 81-97 points). This conforms to the results of Dome osteotomy and distal soft tissue procedures in the literature. However, most of the literature reports had a heterogeneous group of mild, moderate and severe hallux valgus. To the best of our knowledge, this is the first series of only severe hallux valgus treated by proximal dome osteotomy, distal soft tissue lateral release and medial repair^[3,4,13,20]. The modification of adding Z-plasty of the extensor hallux longus tendon to the distal soft tissue procedure (to reduce the possibility of recurrence by decreasing the bowstring effect of the EHL after deformity correction by osteotomy) may play a role in having only two cases of recurrence in this series of severe hallux valgus after surgery.

The rate of permanent complications in this series was in four patients (13%) but none of our patients complained of transfer metatarsalgia with or without plantar callosity beneath the second metatarsal head and only one patient had osteoarthritis in the 1st MTP joint. The rate of complications in this study is very similar to what is mentioned in other reports in the literature^[7,9,21,22]. Proximal crescentic metatarsal osteotomy with distal soft tissue procedure modified by extensor hallucis longus Z-plasty has proved effective in relieving symptoms and in restoring feet appearance in severe hallux valgus deformity to nearly normal shape and function with a low rate of recurrence and other complications. The significance of the impact of our distal soft tissue modification in hallux valgus correction surgery will need further evidence by planning a randomized prospective study.

CONCLUSION

We believe according to the results of this study and other reports in the literature that the proximal crescentic metatarsal osteotomy combined with distal lateral release, medial repair and lengthening of the EHL is a reliable and successful surgical technique in treating severe hallux valgus deformity in adult feet. The technique is simple, has a low rate of complications and is associated with durable correction relieving the patients' symptoms enough to justify its recommendation.

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