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Clinical Comparison Between Shortening Osteotomy of the Proximal Phalanx Neck and Arthrodesis in Hammer Toe Surgery at Mid-Term Follow-Up

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ABSTRACT

The treatment of hammer toe has been advocated for years, and many procedures have been proposed with skeletal and soft tissue intervention. The purpose of the present study was to compare arthrodesis of the proximal interphalangeal joint with shortening osteotomy of the proximal phalanx neck. In most cases, both procedures have been associated with elongation of the extensor apparatus, capsulotomy of the metatarsophalangeal joint, and stabilization with a Kirschner wire. To experiment with a technique that respects the anatomy and joint function, we used a distal subtraction osteotomy of the proximal phalanx neck. We compared a series of 78 patients, divided in to 2 groups: 38 (48.7%) treated with arthrodesis and 40 (51.3%) with shortening osteotomy. Patients were aged 22 to 78 years, with a mean final follow-up period of 56.6 (range 24 to 96) months. For clinical evaluation, we used the American Orthopaedic Foot and Ankle Society score, Foot and Ankle Outcome Score, and a subjective rating scale. The results were comparable between the 2 techniques; however, we report faster functional recovery in the group treated with shortening osteotomy ($p < .0001$), with an adjunctive advantage of preserving the integrity of the proximal interphalangeal joint. Thus, according to our results, this technique is comparable to arthrodesis.

Hammer toe deformity of the lateral toes is characterized by flexion of the proximal interphalangeal joint (PIPJ), associated with the hyperextension of the metatarsophalangeal joint (MTPJ) and the neutral, sometimes hyperextended, position of the distal interphalangeal joint (1). The indications for surgery depend on the degree of the deformity and the severity of the pain.

Myriad procedures for the correction of hammer toe deformities have been described (2–4). Lesser toe interphalangeal joint fusion is 1 of the more commonly performed procedures in foot and ankle surgery (5). Arthrodesis is performed by the resection of the 2 articular surfaces that are fixed temporarily with a Kirschner wire to stabilize the joint and reduce the recurrence rate.

Arthrodesis is indicated for severe and irreducible hammer toes; the most commonly used is the end-to-end procedure. It is important to have a parallel PIPJ following bone resection to prevent varus–valgus or flexion–extension deformity (6). Bone resection reduces the tension in the soft tissues and conserves an appropriate toe length. In an effort to preserve the PIPJ while reducing tension and maintaining length, we performed a subtraction osteotomy at the proximal phalanx neck and compared the clinical outcome of this technique with that of arthrodesis. Regarding the occurrence of insufficient correction, longer operative times are often necessary at the level of the MTPJ, which consists of the release of the joint, lengthening of the extensor apparatus, and possible fixation of the MTPJ with a Kirschner wire. In a few cases, a percutaneous tenotomy of the long extensor according to McGlamry will be sufficient (6–8).

Thus, as we reported in a previous study, we introduced a shortening osteotomy of the proximal phalanx neck to obtain stable and lasting correction of the deformity, preservation of the joint motion of the PIPJ, and bony union, with the characteristics of minimal invasiveness (6). Furthermore, we reviewed 2 groups of patients who underwent shortening osteotomy of the proximal phalanx and arthrodesis for treatment of hammer toe deformity, with the aim of determining differences in the clinical outcomes associated with these interventions. The purpose of the present study was to review the results of patients undergoing either shortening osteotomy of the proximal phalanx or PIPJ arthrodesis

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Table 1
Statistical description of the study

Study Characteristics	Arthrodesis (n = 38 Patients/61 Toes)	Subtraction Osteotomy (n = 40 Patients/55 Toes)
Age	69.6	65
Sex	Male 8; female 30	Male 5; female 35
Side	Right 21; left 17	Right 22; left 18
Follow-up (months)	60.4 (range 24 to 94)	52.8 (range 24 to 94)
Associated hallux valgus	24	28
Time K-wire removal	5.3 (range 4 to 8)	4 (range 2 to 6)
Time of bone healing (weeks)	5.4 (range 5 to 8)	4.3 (range 3 to 6)

for the treatment of hammer toe deformity by determining the differences in clinical outcomes associated with these interventions.

Patients and Methods

The present study was a retrospective analysis of 78 enrolled patients with rigid hammer toe deformity (78 feet and 116 toes) who underwent surgery between January 2006 and December 2011 with arthrodesis of the PIPJ (group A, n = 38) or subtraction osteotomy (group B, n = 40) of the proximal phalanx neck. The mean age of the patients was 67.3 (range 22 to 78) years: 69.6 years for group A and 65 years for group B. Of the 78 patients, 65 were female and 13 were male; 43 right feet and 35 left feet. In 78 cases, the second toe was affected; in 26 cases, the third toe; and in 12 cases, the fourth toe (Table 1)

We evaluated only patients treated unilaterally to avoid more complex cases and to more easily compare the 2 groups. The preoperative interphalangeal angle in the anteroposterior view ranged from 0° to 5° in all patients included in the present study. Patients with dislocated, irreducible MTPJs were excluded. Inclusion criteria were patients aged 18 to 80 years with no major medical comorbidities (i.e., cancer, stroke, peripheral vascular disease, neuropathy, or uncontrolled diabetes), and who were active in daily recreational activities. All surgeries (arthrodesis and osteotomy) were performed by 2 surgeons (A.C. and P.C.).

All patients were evaluated pre- and postoperatively by clinical and radiographic examinations, with follow-up visits at 4 and 6 weeks postoperatively and a final visit at a mean of 56.6 (range 24 to 96) months. No patients were lost during follow-up. As reported in our previous study, patients with dislocated, irreducible MTPJs were treated using another method and were excluded from the present study. Hallux valgus correction with Austin-Chevron or Scarf osteotomies was performed in 52 patients simultaneously (9,10) (Table 1).

Clinical assessment was based on the American Orthopaedic Foot and Ankle Society (AOFAS) score for lesser toes and the Foot and Ankle Outcome Score (FAOS) at the final follow-up (11–13). A subjective rating scale was used for the patients to evaluate their results. The patients were asked to rate their satisfaction with their ability to wear normal shoes and perform their normal daily activities following surgery. The patients rated their result as excellent, good, fair, or poor. A rating of excellent indicated that the patient had no pain, walked without difficulty, and was very satisfied with the result. A rating of good indicated that minimal pain was present and the patient was satisfied with the result. A rating of fair indicated that the patient had moderate residual foot pain and walked with some difficulty. A rating of poor indicated that the patient continued to have foot pain, walked with difficulty, and regretted undergoing the procedure (6). All patients were radiographically evaluated both pre- and postoperatively with anteroposterior and lateral weightbearing radiographs. Data were extracted from the medical records by 2 authors (A.C., P.C.), and statistical analyses were carried out by 2 authors (G.R., P.C.). All radiological measurements were taken by an orthopedic surgeon (P.C.) and a radiologist who were blinded to the type of surgical procedure performed and were not inserted in the study. The present study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki; informed written consent was obtained from all patients.

Surgical Techniques

Following antibiotic prophylaxis and peripheral block anesthesia, the patient was positioned supine on the operating table, with a 250 mm Hg tourniquet at the ankle. Through a 10- to 12-mm dorsal transverse incision at the level of the PIPJ, subtraction osteotomy at the distal metaphysis of the proximal phalanx was made. The osteotomy was performed, with the first cut 3 to 4 mm proximal to the joint, perpendicular to the axis of the phalanx. The second cut was performed parallel to the first, a few millimeters proximal. The greater the need for correction in relation to the severity of the deformity, the larger the cut. A Kirschner wire, 1.4 mm in diameter, was driven anterograde, first into the distal fragment of the head and then out at the tip of the toe into its center, positioning the head during insertion of the wire pin parallel to the second phalanx along its own axis, ensuring that the wire was in the center of the tip of the toe. This should not be performed too dorsally to avoid any possible damage to the nail bed or too plantarly to avoid any malunion or bony union with hyperextension of the distal osteotomy fragment. At that point, the Kirschner wire was inserted retrograde into the proximal fragment to stabilize the correction (6).

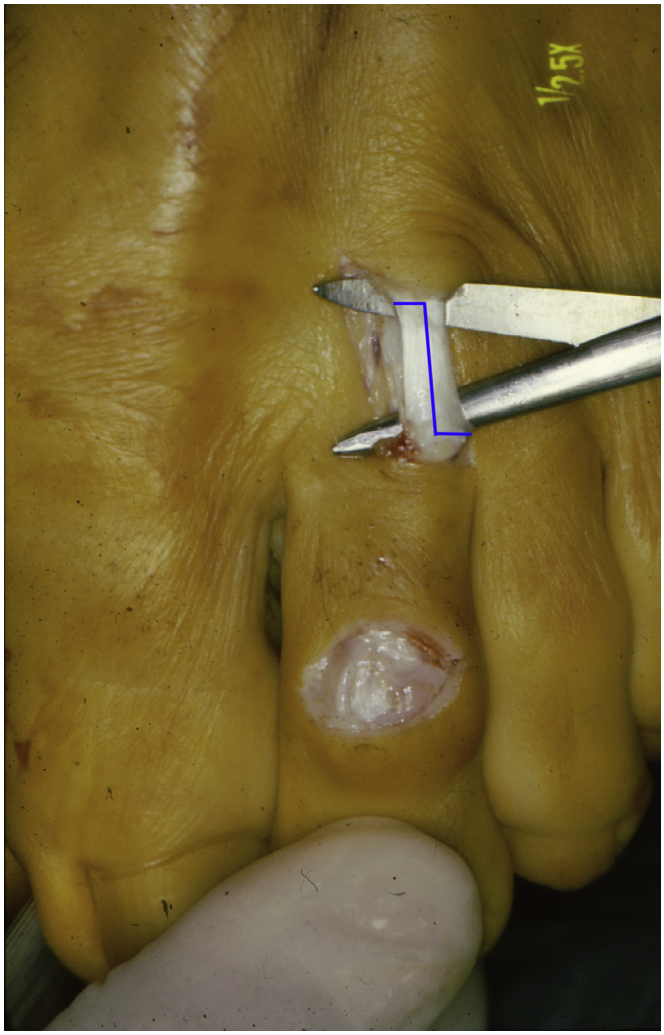

Fig. 1. Z procedure to elongate the extensor digitorum longus tendon.

In the case of the arthrodesis, the ligaments and tendons were cut to help straighten the toe. The cartilage surface of the PIPJ was cut, and the toe was straightened. In the toes in which we observed an evident elevation of the operated toe at the end of the surgical procedure, we performed a Z procedure to lengthen the extensor digitorum longus of the treated toe and dorsal capsulotomy of the MTPJ (Fig. 1). Adjunct surgical correction of associated forefoot deformities, such as hallux valgus, was also corrected as determined necessary by the surgeon and the patient (6).

Statistical Analysis

The nonparametric Wilcoxon test for paired data was used to compare the scores before and following surgery. Statistical analysis was performed using IBM SPSS software, version 22.0, 2013 (IBM Corp, Armonk, NY). We defined statistical significance at the 5% level ($p \leq .05$).

Results

Fifty-two (66.6%) patients displayed hallux valgus, and no patients showed other deformities (Fig. 2). In the preoperative AOFAS evaluation, all patients reported pain at the PIPJ because of conflict between the toe and the shoe and limitations of daily activities. The joints were unstable in most patients, and the presence of symptomatic hyperkeratosis at the level of the head of the first phalanx was observed in almost all patients. The FAOS was reported only at the final follow-up in the 2 groups.

The interphalangeal angle at diagnosis was normal (range 0° to 5°) on the anteroposterior view in all patients in the present study. In the

Fig. 2. Preoperative anteroposterior and lateral view of a hammer toe previously treated for hallux valgus with the Austin-Chevron technique. SC, weightbearing x-ray; SN, left.

lateral view, the mean preoperative interphalangeal angle was 68.56° (range 38° to 90°) for group A and 65.34° (range 40° to 90°) for group B, and a significant improvement ($p < .0001$) in the interphalangeal angle was observed on the lateral views, with a median value of 11° (range 0° to 20°) and no statistical difference between techniques. The axis in the anteroposterior view was maintained as normal.

Using the subjective rating scale, satisfaction was excellent for 30 patients in group A and 35 patients in group B (85% vs 76%, $p < .005$), with better patient agreement in the osteotomy group (Table 2). All patients were evaluated at a mean final follow-up visit at 56.6 (range 24 to 96) months. The postoperative results included a significant increase ($p < .0001$) in the median global AOFAS score from 28 (range 24 to 34) points to 89.6 (range 80 to 98) points in the subtraction osteotomy group and from 30 (range 24 to 36) points to 83.4 (range 76 to 95) in the arthrodesis group (Fig. 3).

Median FAOS, calculated in all patients postoperatively, was as follows: 92 versus 90 (range 52 to 100) for the category of pain, 78 versus 84 (range 46 to 90) for symptoms and stiffness, 84 versus 92 (range 28 to 100) for activities of daily living, 78 versus 80 (range 20 to 100) for sports and recreation, and 87 versus 89 (range 46 to 100) for quality of life (Fig. 4). The average interval to bony union was 5.4 (range 4 to 7) weeks in group A and 4.3 (range 3 to 6) weeks in group B ($p < .005$) (Figs. 5 and 6). No major complications were observed.

In group A, we reported 4 cases of nonunion (3 asymptomatic) and 2 cases of loss of correction but no cases of malunion. In 4 of the 61 toes, a revision surgery was necessary (6.5%). In group B, the observed complications included 2 cases of loss of correction: 1 from insufficient shortening and 1 from imperfect positioning of the Kirschner wire. A revision surgery was performed in 2 of the 55 toes (3.6%) (Table 2). In group B patients with a follow-up period >5 years (14 of 55 patients), we observed stiffness of the toes (range of motion <10°) in 10 cases (71%) but with no symptoms.

Table 2
Outcomes of clinical evaluations scores

Variable	Arthrodesis (n = 38)	Subtraction Osteotomy (n = 40)	*P* Value
Preoperative AOFAS	30 (range 24 to 36)	28 (range 24 to 34)	>.005
Postoperative AOFAS	84 (range 76 to 95)	89 (range 80 to 98)	<.005
Postoperative FAOS			
Pain	92 (range 52 to 100)	90 (range 52 to 100)	>.005
Symptoms/stiffness	78 (range 46 to 90)	84 (range 46 to 90)	<.005
Activities daily living	84 (range 28 to 100)	92 (range 28 to 100)	<.005
Sports	78 (range 20 to 100)	80 (range 20 to 100)	>.005
Quality of life	87 (range 46 to 100)	89 (range 46 to 100)	>.005
Postoperative subjective satisfaction			
Excellent	29/38 (76.3%)	35/40 (87.5%)	
Good	5/38 (13.1%)	2/40 (5%)	
Fair	3/38 (7.9%)	3/40 (7.5)	
Poor	1/38 (2.6%)	0	
Complications			
Nonunions	4/61 (6.5%)	0	
Loss of correction	2/61 (3.2%)	3/55 (5.45%)	
Revision surgery	4/61 (6.5%)	2/55 (3.6%)	
Asymptomatic	NA	10/55 (18.1%)	
Stiffness			

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; FAOS, Foot and Ankle Outcome Score.
Data are presented as 29 out of 38 patients (total arthrodesis percentage).

Discussion

Numerous surgical techniques have been described for the correction of hammer toe deformity, each possessing advantages and disadvantages. The present comparison should be useful for in-depth understanding of the functional results of hammer toe correction with 2 similar techniques.

Baig and Geary (14) examined 19 patients (42 toes) who had undergone arthrodesis at the PIPJ and fixed with a Kirschner wire. They reported fusion after 6 months in 83% of the patients; however, an 11% reoperation rate for instability or deformity of the distal interphalangeal joint was also reported. Caterini et al (15) evaluated 24 patients (51 toes) treated with arthrodesis of the PIPJ and stabilized with a cannulated titanium screw. They reported a mean AOFAS score of 86.54 points at the final follow-up visit (2.6 years); however, in 7 cases (13.7%),

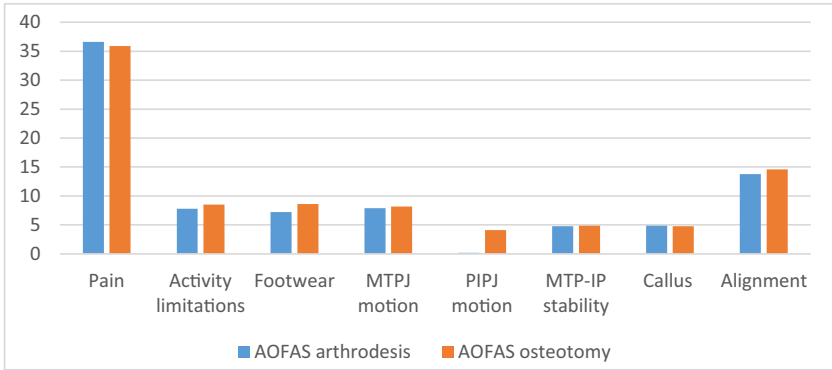

Fig. 3. AOFAS postoperative scores in 2 groups (n = 38 arthrodeses and n = 40 osteotomies). AOFAS, American Orthopaedic Foot and Ankle Society; MTPJ, metatarsophalangeal joint; MTP-IP, metatarsophalangeal-interphalangeal; PIPJ, proximal interphalangeal joint.

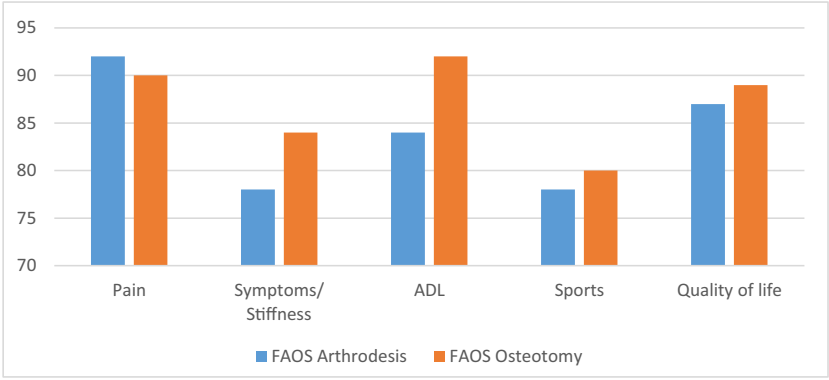

Fig. 4. FAOS clinical outcomes in 2 groups (n = 38 arthrodeses and n = 40 osteotomies). ADL, activities of daily living; FAOS, Foot and Ankle Outcome Score.

Fig. 5. Results shown in the (*A*) lateral and (*B*) anteroposterior views, with arthrodesis of the proximal interphalangeal joint DX ORTOST, right weightbearing x-ray.

screw removal was necessary. Unsdorfer and Unsdorfer (16) suggested performing arthrodesis of the PIPJ in conjunction with proximal osteotomy of the base of the first phalanx, with a mean AOFAS score of 91.27 in 15 patients (20 toes) being reported.

The present study shows that subtraction osteotomy of the proximal phalanx neck allowed stabilization of the PIPJ, recovery of the deficiency of the second ray, and correction of the biomechanical and radiographic parameters. In our opinion, subtraction osteotomy created a state in which the postoperative PIPJ maintained stability, which arthroplasty does not, and allowed slight bending without the rigid stiffness of arthrodesis. Moreover, arthrodesis has previously shown a percentage of fibrous union ranging from 3% to 19%, even though asymptomatic nonunion was present in most cases (7,8,17). In our series, we observed similar results for arthrodesis, and almost all of the nonunion cases (3 of 4) were asymptomatic. Recently, Schrier et al (18) compared PIPJ resection and fusion, with the authors concluding that no clinical difference was observed between PIPJ fusion and resection in the treatment of rigid PIP flexion deformity. Both procedures resulted in good to excellent outcomes in pain and activity scores; however, it remains

Fig. 6. Results shown in the (*A*) anteroposterior and (*B*) lateral views, with conservation of the proximal interphalangeal joint SN, left.

disputable whether better alignment in the sagittal plane would justify greater use of PIPJ fusion.

Richman et al (19) compared the correction of hammer toe deformity with intramedullary PIP fusion versus Kirschner wire fixation, concluding that complications were significantly higher in the Kirschner wire group than those in the intramedullary group, even if the power of the study was limited by the short length of the follow-up period and the small sample size.

In the present study, we did not observe any cases of nonunion in the osteotomy group. We believe that osteotomy in the distal metaphyseal region reduces the risk of nonunion because this area is greatly vascularized; however, we reported stiffness in the patients with longer follow-up periods but without symptoms and with excellent satisfaction because of pain relief (6). Shortening osteotomy, if performed well, provides rapid consolidation of the osteotomy, early removal of the Kirschner wire, return to daily activities and work within 4 weeks, and joint preservation that is well accepted by patients (20). The postoperative results show a significant increase ($p < .0001$) in the median global AOFAS and FAOS numbers. The FAOS was used because it has been standardized for the evaluation of outcomes following foot and ankle surgery, and the AOFAS forefoot score was also calculated because it was the most used score system in our literature research; however, we are not aware of any validated outcome score specific to hammer toe correction. We believe that by using a subjective rating scale and analyzing radiographic changes, our outcomes of interest reasonably reflect the needs of each patient.

Both techniques have shown an ease of execution and excellent corrective capacity; however, preservation of articular mobility is possible only with osteotomy. As reported in our previous study, the procedure requires the width of the osteotomy to be determined according to the degree of the deformity; the joint surfaces should be precisely united; and the Kirschner wire should be inserted into the distal fragment of the osteotomy, along the axis of the toe, with the exit at the center of the tip of the toe. The present study shows that both techniques reported good to excellent results and are equally effective for the treatment of hammer toe, without the use of expensive devices and with high patient satisfaction. At the final follow-up, the higher AOFAS and FAOS numbers in the group treated with shortening osteotomy can be explained by the preserved PIPJ, which provides 5 points; however, no differences in shoe wearing or pain were observed.

The main limitation of the present study, although comparing 2 surgical procedures, is the retrospective design and lack of randomization. Moreover, our subjective results were likely influenced by surgical correction of adjunct deformities, as well as hammer toe correction, and we did not perform analyses that enable us to distinguish the precise influence that any particular intervention may have had on the outcome. Inclusion of patients with simultaneous hallux valgus correction could also be considered a defect of our study design. Furthermore, only 1 of the 2 surgeons assessed the patient satisfaction rate; therefore, a bias is potentially present because the surgeon determined this outcome of interest and noted this in the medical records.

In conclusion, the present study demonstrates that both techniques can lead to considerable correction, pain relief, and good radiographic results; nevertheless, considering the biomechanical parameters, preservation of the integrity of the PIPJ, and a more rapid functional recovery, we still prefer to use shortening osteotomy of the PIPJ.

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