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Original Research

Treatment of irreducible second metatarsophalangeal joint dislocation by double percutaneous osteotomy: Haspell and distal metatarsal mini-invasive osteotomy

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ABSTRACT

Subluxation or dislocation of the second metatarsophalangeal joint may be commonly associated with crossover toe, metatarsalgia, and painful calluses. This retrospective study aims to evaluate the clinical and functional results in patients with irreducible second metatarsophalangeal joint dislocation treated by double percutaneous osteotomy in one step: Haspell's osteotomy and Distal Metatarsal Mini-Invasive Osteotomy. A total of 39 patients were included in this study. 31 patients had a simultaneous procedure on the first ray for hallux valgus correction. The American Orthopaedic Foot and Ankle Society score (AOFAS), the degree of joint range of motion (ROM) and hyperkeratosis of the second ray were assessed as outcomes at the baseline (T0), at 6 months (T1), and at 1 year (T2) from surgery. The mean pre-operative AOFAS score was 62.76 ± 5.5, at 6 months after surgery it increased to a value of 78.81 ± 8.15 and at one year to a value of 88.78± 6.51. No differences in term of ROM were found between pre and postoperative values at 6 months. A significant improvement in ROM at 12 months was found. Hyperkeratosis, assessed with a nominal scale classification, decreased statistically significantly and, one year after surgery, in 88.88 % of cases they completely resolved. The double percutaneous osteotomy brings advantages in terms of pain reduction. In conclusion, DMMO associated with Haspell's osteotomy is a safe and effective and reproducible technique in the resolution of metatarsalgia in patient with irreducible instability of the second metatarsophalangeal joint.
Level of Clinical Evidence: 4

Introduction

Lesser metatarsophalangeal joint instability (MTPJ) can be a cause of metatarsalgia, a painful condition that commonly involves the forefoot and impairs the biomechanics of gait [1]. This condition is defined as a dorsal subluxation or dislocation of the proximal phalanx on the metatarsal head with deformities in both the sagittal and transverse planes and resulting in claw and crossed fingers [2]. Instability is most frequently found in the second metatarsophalangeal joint, but it can affect all MTPJ [3]. The plantar plate, collateral ligaments and joint capsule are passive stabilizers of the joint. Intrinsic and extrinsic muscles are active stabilizers of MTPJ. It is clear that joint instability results from a weakening of these structures, especially of the plantar plate [4]. Lesser MTPJ instability has an idiopathic origin. Secondary factors that contribute to the onset of this condition are: second long metatarsal, hypermobility of the first ray, hallux valgus, use of footwear that cause the hyperload on the metatarsal heads [5]. According to Thompson and Hamilton's classification at stage 0 there is no dorsal translocation of the proximal phalanx. In stage 1, the phalangeal base may undergo a dorsal subluxation but not a dislocation. In stage 2, the phalangeal base may be dislocated but may be reduced manually. In phase 3, the phalangeal base is in a fixed dislocated position [6]. The dislocation can be irreducible if the plantar plate and capsule are interposed in the joint space [7]. Hammertoes lose their function in the push-off phase of the gait, thus

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functionally uncovering the metatarsal heads which, over time, develop calluses due to overload. The distalization of the plantar plate also contributes to the formation of the calluse. Calluses are processes of hyperkeratosis, keratinization of the stratum corneum of the skin increases, in response to repeated traumatic insults of various kinds [8–10]. Therefore, the pathology will manifest clinically with hyperkeratotic lesion on the plantar side of the forefoot, pain during walking and painful calluses above the proximal interphalangeal joint due to the friction created by the shoe, swelling at the level of the joint and dysfunction. Irreducible dislocation of II MTPJ and metatarsalgia causes pain resulting in limitations in daily activities for patients, who report difficulty wearing footwear and limitations in weight-bearing activities. In addition, there is a strong discomfort in the psychological sphere due to the aesthetic appearance of the feet characterized by deformities in claws, crossed toes and plantar hyperkeratosis.

Diagnosis is clinical by vertical stress testing to identify instability of the metatarsophalangeal joint in the sagittal plane. The drawer sign is the first objective sign of instability of the metatarsophalangeal joint [11]. Imaging techniques can support diagnosis such as DP-LL X-Ray which will show subluxation or dislocation of the MTPJ involved and MRI which will show the plantar plate injury. Imaging can help clarify concomitant and contributory pathological features, such as hallux valgus or a second long metatarsal.

Conservative treatment (activity modification, orthotics, metatarsal pads, modified shoes, and toe braces) are not conclusive [12]. Surgery is necessary when conservative treatment fails. Several surgical techniques are described in literature including: direct plantar plate repair, transfer of the Girdlestone-Taylor flexor to the extensor tendon, condylectomy, Weil osteotomy, DMMO or a combination of the same [13].

Our primary aim was to find an alternative to metatarsal condylectomy, using a less traumatic approach and evaluate the clinical and functional results in patients with irreducible second metatarsophalangeal joint dislocation. Our secondary aim was to assess patient satisfaction. Reducing dislocation was not objective of the surgery.

Patients and methods

Patients selection

From December 2019 to January 2021, thirty-nine (39) consecutive patients with irreducible II metatarsophalangeal joint dislocation and metatarsalgia were enrolled in this study. Thirty-one patients (31) were women and eight (8) were men. The age ranged from 44 to 82 years (mean age 64 years). Thirty-one patients had a simultaneous procedure on the first ray for hallux valgus (HV) correction with no internal fixation. The “without osteosynthesis” (WOS) technique, a minimally invasive percutaneous approach, has been proposed as an effective treatment option [22]. In this technique, the percutaneous osteotomy with a 2.0 mm × 12.0 mm Shannon burr were performed extracapsulary in the subcapital region, perpendicular to longitudinal axis. The head can be translated up to 90 % of first ray shaft diameter to recentering the sesamoids. In case of high DMAA with a curved proximal phalanx, Akin osteotomy was performed with 2.0 mm × 12.0 mm Shannon Burr [18].

All patients were informed and gave their consent to the publication of the data. The surgical procedures were performed by one surgeon, Fabio Zanchini, MD, PhD, Professor, the supporter of MIS in southern Italy, who followed the patients in the outpatient evaluation.

The inclusion criteria were: symptomatic instability of MTPJ after at least 6 months of conservative treatment without acceptable results (persistent pain), grade 3 of irreducible instability according to the Thompson and Hamilton’s classification, grade 1 and 2 of calluses according to a nominal scale classification [15]. Patients with concurrent deformities in the lesser toe and hallux valgus that required an accessory surgical time of correction were also included. Patients who underwent previous HV correction surgery on the same side, with hallux rigidus, a degenerative arthritic condition affecting the first metatarsophalangeal joint; flat foot with joint laxity and the collapse of the medial longitudinal arch, eversion of the rearfoot and abduction of the loaded forefoot; rheumatoid arthritis; inflammatory conditions were excluded. Patients with diabetes, peripheral neuropathy, patients suffering of higher grade of varicosity [21], psychiatric, cancer disease [23] and infectious diseases were excluded.

Clinical evaluation

The American Orthopaedic Foot and Ankle Society (AOFAS) scale was performed preoperatively, at 6 months, and the last follow-up (12 months) for a maximum of 100 points divided into the following categories: pain (max 40 points), function (max 45 points), and toe alignment (max 15 points) [14]. The ROM evaluation was performed preoperatively, at 6 months, and then at the last follow-up, analyzing the global extension and flection of the metatarsophalangeal joint [14]. ROM is considered normal or mildly limited if $\geq 75^{\circ}$, moderately limited if between 30° and 74°, severely limited if $<30^{\circ}$. Hyperkeratoses of the second ray were classified based on clinical observation with reference to a nominal scale. This scale is divided as follows: grade 1- Callosity shows no border symmetry and maybe diffusely spread without any concentrated area of keratinization; grade 2- The border is discrete and may be raised forming a button or disc of thickening; grade 3- lesion has no surrounding callus except at the extreme border where a thickened ring or rim may exist; grade 4- The callus will have a circumscribed symmetrical or asymmetrical area of greater depth, ridge or greater concentration anywhere within the callus [15].

Statistical analysis

We used the paired t-test using SigmaPlot software (Systat Software Inc., San Jose, A, USA) to compare the values recorded at time 0 (preoperative) with the values recorded at 6 months and 1 year for all patients. The p-value was set at $p < 0.05$.

Surgical technique

The first surgical step is Haspell’s osteotomy [16]. Haspell’s osteotomy is performed on the plantar face of the metatarsal head. The purpose of the technique is to reduce the size of the metatarsal head. The first surgical step consists in identifying the metatarsal head under fluoroscopic control. Minimal skin incision (3-4 mm) is made on the distal plantar face of metatarsal head, using a Beaver 64 scalpel. The osteotomy is performed with 2.0 × 12 mm Shannon Burr in the width direction of the second metatarsal head. It is removed from a third to half of the plantar surface of the metatarsal head under fluoroscopic control. The removal of bone debris is performed through the use of the rasp. This in order to reduce the risk of recrudescence.

Distal Metatarsal Minimally Invasive Osteotomy (DMMO) [17] is second surgical step. This tecnique is performed with minimally invasive surgery (MIS). In all patients, a second, third, and fourth DMMO was performed. A Beaver 64 is used for skin incision, parallel to the extensor tendons. The scalpel is advanced at an oblique angle of about 45 degrees until it reaches the dorsal aspect of the metatarsal (MT) neck to undergo distal osteotomy. Fluoroscopy is used to confirm the correct position of the osteotomy site on the MT neck and the angle of cut. This technique proximalizes and elevates the head of the metatarsal, reducing the patient’s metatarsalgia.

Double osteotomy is combined with different surgical procedures in the presence of associated deformities: Reverdin-Isham osteotomy for hallux valgus (HV) deformity, dorsal MTPJ capsulectomy, flexor and extensor tenotomies with distal phalangeal percutaneous osteotomy for lesser toe deformities.

This will be followed by a corrective bandage and the use of a postoperative flat sole and rigid shoe for 5 weeks.

Table 1
The main clinical features of patients included in the study preoperatively, at 6 months, and at the last follow-up.

	Preop	6 months	Last follow-up	
AOFAS	62.76 +/ 5.5	78.81 +/5	88.78 +/6.51	Mean +/ DEV.st
ROM	64.94 +/ 9.19	66.18 +/10.44	80.71 +/ 5.82	Mean +/ DEV.st

Results

The AOFAS score improved statistically significantly at 6 months and one year postoperatively compared to the preoperative score ($p < 0.05$).

Hyperkeratosis at 6 months improved statistically significantly ($p < 0.05$) and there was a statistically significant increase at one year compared to both the value recorded at 6 months ($p < 0.05$) and compared to the preoperative value ($p < 0.05$). It has been reported that the restoration of the physiological biomechanics of the forefoot is correlated with a reduction in the degree of plantar callosity, which in 88.88 % of cases resolved 12 months after surgery.

No differences were found in terms of ROM at 6 months ($p = 0.37$), but there was a statistically significant improvement at 12 months ($p < 0.05$)

Outcomes at the baseline (T0), at 6 months (T1), and at 1 year (T2) from surgery were reported in Table 1, while the clinical feature is reported in Figs. 1–3.

X-rays of a case before surgery, immediately after surgery and 3 months after surgery are shown in Figs. 4–6.

Complications and management

No floating-toe complication, a forefoot deformity wherein the distal portion of the toe does not establish touch with the ground, resulting in a suspended or elevated position while the finger is in a relaxed state; no case of hallux varus due to iatrogenic hypercorrection were reported.

In two cases, joint stiffness was reported, but with adequate physiotherapy and active and passive mobilization exercises and gait education, it was completely resolved.

Thirty-one patients had a simultaneous procedure on the first ray for hallux valgus (HV) correction with no internal fixation (WOS technique). Two of these patients developed a superficial infection at the medial access to exostosis, all resolved by general and local antibiotic therapy for 4 weeks.

Fig. 1. Preoperative and post-operative clinical features of a 66 years female patient with hallux valgus, irreducible II-III metatarsophalangeal joint dislocation and metatarsalgia.

Fig. 2. Preoperative and post-operative clinical features of a 66 years female patient with hallux valgus, irreducible II-III metatarsophalangeal joint dislocation and metatarsalgia.

Fig. 3. Preoperative and post-operative plantar hyperkeratosis.

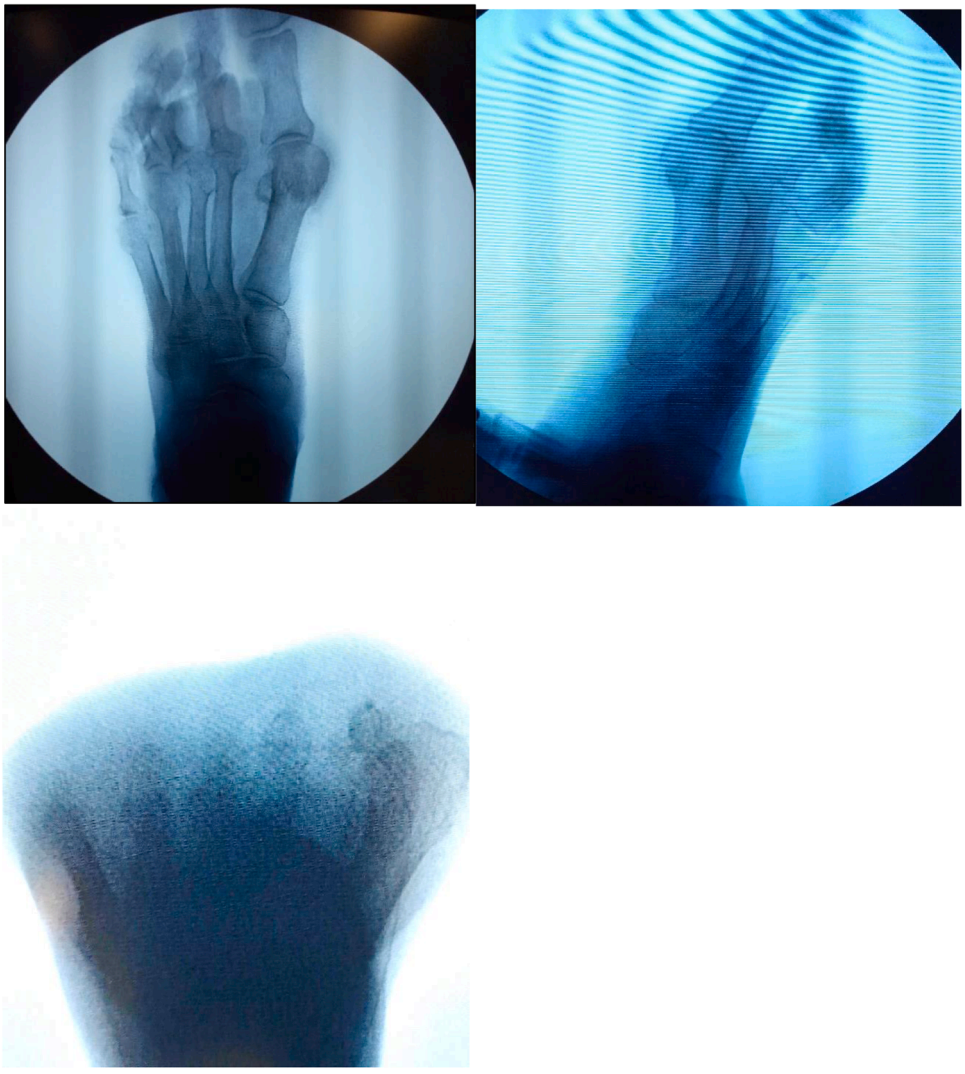

Fig. 4. Preoperative radiological features of a 64 years female patient hallux valgus, irreducible II metatarsophalangeal joint dislocation and metatarsalgia.

Discussion

The aim of this retrospective study was to find an alternative to metatarsal condylectomy, using a less traumatic approach. DuVries described the condylectomy for the treatment of isolated, intractable, plantar keratotes but it was associated to reduction in ROM of MTPJ [20]. To our knowledge, there is no literature that discusses cases of irreducible luxation of a non-traumatic nature. Literature studies deal with cases of lesser metatarsophalangeal joint instability and the techniques described concern plantar plate repair, flexor tendon transfer to

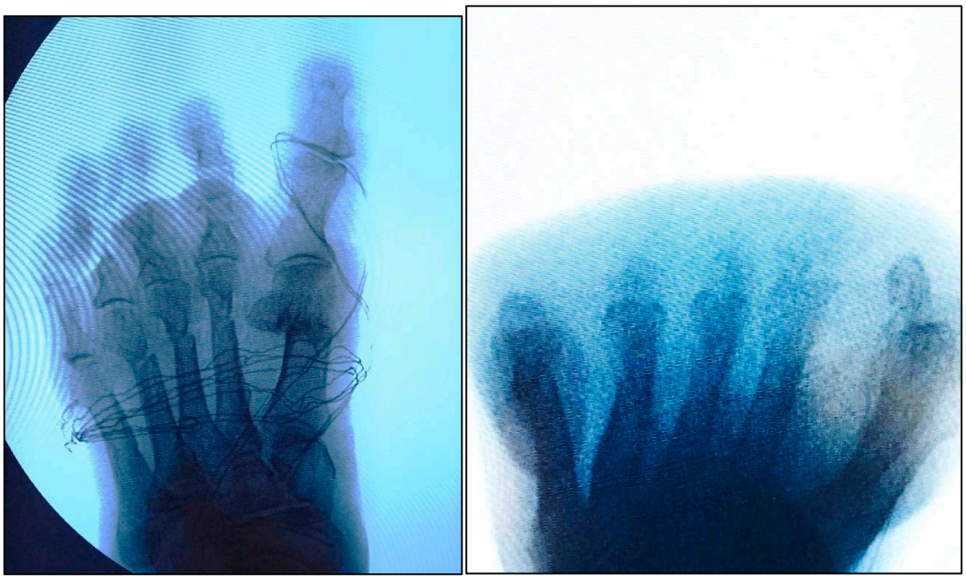

Fig. 5. Immediately postoperative fluoroscopic picture of the patient treated with double percutaneous osteotomy: DMMO and Haspell without fixation (bandages).

Fig. 6. 3 months postoperative fluoroscopic picture.

the extensor tendon (performed alone or more often in association with Weil's osteotomy).

We performed the tecnique with a minimally invasive approach. The advantages of the MIS technique are: minimal skin incisions (3-4 mm), no internal fixation (K-wire or screw), low complication rate (implant migration, infection, fixation irritation) and immediate post-operative walking. Weightbearing was allowed immediately after surgery with a flat sole and rigid shoe. The bandage was maintained for 5 weeks [18]. Loading without this type of sole would cause an excessive extension of the metatarsophalangeal joint with consequent displacement and rotation of the osteotomized metatarsal head [16]. The corrective bandages have made it possible to obtain good and rapid functional results and to avoid the phenomenon of Floating toe. The minimally invasive surgical approach allows for rapid functional recovery due to the fact that it does not interfere with surrounding anatomical structures [19].

Early weight-bearing, minimal invasiveness, minimum instrumentation required to perform the technique represent this technique's advantages. The disadvantage of Haspell's osteotomy is the difficulty of intra-operative and post-operative radiographic verification.

This tecnique is reserved for cases of severe plantar hyperpressure as an alternative to the total removal of the metatarsal head. The technique doesn't reduce the luxation. Despite this, the patient is satisfied with the resolution of the pain and the crossover toe.

Double osteotomy brings a number of advantages in terms of pain reduction. While with DMMO we proximalize and lift the metatarsal head reducing the hyperload on it and therefore metatarsalgia, by also

adding Haspell's osteotomy we reduce the size of the hypertrophic metatarsal head bringing a greater reduction in pain and plantar hyperkeratosis. In our group of patients, there were no major complications or need for surgical reintervention.

Several limitations exist for our study including small sample size, there is a high rate of patients undergoing surgical correction of hallux valgus deformity with no control group.

Despite the small number of our study, the results obtained in terms of improvement in pain, joint function and painful plantar calluses seem encouraging.

In conclusion, the double percutaneous osteotomy DMMO and Haspell is a safe, effective and reproducible technique in the resolution of metatarsalgia and irreducible instability of the second metatarsophalangeal joint.

There is no data in the literature on Haspell's osteotomy. This study could be useful for foot surgeons to deepen the technique and increase the data in the literature.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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