Technical note

Percutaneous correction of second toe proximal deformity: Proximal interphalangeal release, flexor digitorum brevis tenotomy and proximal phalanx osteotomy

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A B S T R A C T

We report the results of a percutaneous technique to correct a proximal plantar flexion deformity of the second toe that combines several procedures: tenotomy of the Flexor Digitorum Brevis, plantar capuslotomy for release of the proximal interphalangeal joint and proximal phalangeal osteotomy. The goal of these procedures is to improve anatomical correction and preserve articular range of motion. From 2009 to 2011, 54 patients, mean age 64.4 years old (43–81) underwent surgery for a proximal deformity of the second toe. Associated tenotomy of the extensor digitorum longus and brevis was performed in the presence of an extension deformity of the metatarsophalangeal joint (24 cases). After a mean follow-up of 30.7 ± 8.9 months, the rate of satisfaction and morphological correction was high (89.5% in both cases), as well as the number of flexible toes (88%). Active plantar flexion was preserved in 86% of the cases. This seems to be an effective technique to correct proximal plantar flexion deformity of the second toe, while preserving active plantar flexion.

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1. Introduction

There are numerous therapeutic options for lesser toe deformities [1–3] including arthroplasty [4,5], arthrodesis [6,7] and tendon transfers [8–10]. Open surgery is the reference technique but the complications including insufficient correction, associated stiffness and its consequences as well as the long delay before functional recovery reported by certain authors [4,7,10], have resulted in the evaluation of percutaneous treatment of these deformities. In the early part of the 21st century, Mariano De Prado et al. [11] began practicing a percutaneous technique in Europe to overcome the disadvantages of open surgery based on reports of surgery of the first ray by surgeons and podiatrists in the USA, [12,13] as well as numerous studies performed on toe deformities with ulcers in diabetics [14–17]. De Prado et al. [18] described a systematic tenotomy of the flexor digitorum longus (FDL) and the flexor digitorum brevis (FDB) to correct proximal toe deformities that only leaves the interosseous and lumbrical muscles for active plantar flexion. During walking, the toes are in contact with the ground three quarters of the time during the stance phase [19], and this pressure, which is only possible if fat pad strength is preserved, is especially important in athletic patients or patients with proprioceptive disorders [20]. The difficulties described following complete tenotomies in the few reported studies in the literature are moderate. In a study of 188 toes in children, Ross and Menelaus [21] reported no conscious loss of function after 9 years of follow-up despite the poor clinical results of active plantar flexion in 43 cases out of 62. After 1-year of follow-up, Debarge et al. [20] did not report any significant patient dissatisfaction despite a toe grasp function defect, which reduces the propulsion capacity of the toe especially during fast walking and sports. A toe grasp defect can be prevented by avoiding a complete tenotomy (FDL + FDB), thus we described a modification to the original technique that preserved the FDL [22].

The goals of this technical note were:

• to present a surgical technique combining plantar capsulotomy for release of the proximal interphalangeal joint (PIP), selective tenotomy of the FDB and osteotomy of the proximal phalanx (PP) for the correction of proximal deformities of the lesser toes;
• to report encouraging results in a preliminary series of patients treated with this procedure in the second toe.
2. Surgical technique

The patient was installed in the supine position on an adjustable table with the legs apart so that the operated foot could be approached from all sides. Surgery was performed with an ankle tourniquet in case of combined surgery of the first ray. The tourniquet was not necessary if a purely percutaneous procedure was performed. Intraoperative X-ray was used if needed. The procedure combined the following techniques:

- release of the PIP (capsulotomy of the base of the middle phalanx [MP]);
- tenotomy of the 2 distal digitations of the FDB;
- osteotomy of the proximal phalanx;
- ± lengthening of the extensors.

2.1. Capsulotomy of the PIP associated with isolated tenotomy of the FDB

This was performed with the toe in plantar flexion throughout the procedure to prevent collateral plantar nerve damage (Fig. 1). The incision was proximal to the PIP, lateral or medial depending on the operated foot and the surgeon's dominant hand, on the posterior tubercle of the distal epiphysis of the PP palpated with the thumb of the hand that was not holding the beaver. The latter was directly in contact with the bone on the plantar side of the neck of the PP, then continued following the plantar side of the epiphysis of the PP to reach the plantar base of the MP where the plantar portion of the capsule of the PIP was sectioned by a sweeping horizontal movement at the base of the MP, then more distally, the 2 digitations of the FDB.

To confirm complete resection of the 2 digitations of the FDB, a rugine was then inserted, and careful palpation of the entire plantar side of the diaphysis of the MP including the lateral and medial edges was performed. The diaphysis could not be reached with the rugine unless the interphalangeal capsule had been detached.

The released toe was then placed in dorsal flexion by a passive maneuver to confirm reduction of PIP flessum.

2.2. Proximal phalanx osteotomy

This was performed by a plantar approach at the base of the toe, in the metaphyseal area of the PP that preserved the flexor tendons (incision with the operated toe maintained in dorsal flexion to insert the beaver longitudinally in contact with the bone in the area located between the plantar digital fold and bump of the metatarsal head (Fig. 2). Fluoroscopic control was not necessary for experienced surgeons. This incision was medial or lateral depending on the side being operated on and the surgeon’s dominant hand.

A rugine was then inserted to prepare the surgical site for the osteotomy, first at the phalanx then continuing in contact with the bone.

The osteotomy was:

- monocortical, enough to obtain plantar flexion in moderate deformities;
- usually bicortical to obtain the shortening necessary for permanent correction in more severe deformities.

2.3. Tenotomy of the extensors (non-systematic)

This was performed in the area where the two tendons (extensor digitorum longus [EDL] and brevis [EDB]) are separate, that is at the fibroaponeurotic expansion at the metatarsophalangeal joint, so that the “capsule effect” of the expansion could be preserved (anchoring the EDL to the plantar side of the metatarsal head and

**Fig. 1.** Tenotomy of the FDB and plantar capsulotomy of the proximal interphalangeal joint (b) with a beaver: lateral or medial incision, toe in plantar flexion (a).
the base of the PP to prevent proximal retraction of the tendon with toe drop (Figs. 3 and 4).

A plantar flexion maneuver was simultaneously performed on the toe to confirm the success of the procedure: success criteria were tactile, including disappearance of tendon tension, and visual in certain cases, depending on the morphology of the patient. This additional procedure was only performed in the presence of a metatarsophalangeal joint in hyperextension. Pins were not used to maintain reduction, even in cases with associated osteotomies.

3. Postoperative care

Bandaging is very important. It must be performed by the surgeon him/herself at the end of the procedure to maintain the toes in the correct position, using hypoallergenic adhesive Durapore-type bandages (Fig. 5a). Bandages are replaced by the surgeon between D7 and D10 and worn until D21, when it is replaced by a removable orthoplasty until D45 (Fig. 5b).

Immediate weight-bearing is allowed with the patient wearing a semi-rigid shoe that is wide enough to include the bandage for 21 days.

Axial toe traction rehabilitation exercises are performed several times per day by the patient after D8; stretching exercises and exercises to increase range of motion with a physical therapist are begun on D21.

4. Clinical series

Between 2009 and 2011, 283 feet were operated on in our center for lesser toe deformities.

4.1. Inclusion criteria

Inclusion criteria were the presence of a proximal deformity of the second toe, whatever the reducibility, associated or not with metatarsophalangeal hyperextension or requiring associated management of first ray and/or lateral ray deformities.

4.2. Exclusion criteria

Exclusion criteria were the presence of metatarsalgia, severe lesions of the plantar plate on ultrasound or metatarsophalangeal dislocation or subluxation on X-ray resulting in an associated metatarsal osteotomy as well as the presence of osteophytes and arthritis of the PIP and an associated distal interphalangeal deformity.

Fig. 6 presents the flow diagram of our clinical series including 57 feet (54 patients). They were fixed and non-reducible deformities in 42 cases and reducible in 15 cases. Patients were mostly women (53 women/1 man), mean age 64.4 years old ± 8.4 [43–81]. An associated tenotomy of the extensors was performed in 24 cases (42%). The osteotomy of the proximal phalanx was monocortical in 9 cases (15.8%) and bicortical in 48 cases (84.2%).

After a mean follow-up of 30.7 months ± 8.9 [15–49], the results were evaluated by the patient for subjective criteria and by an independent observer by clinical examination for objective criteria: morphological features, passive PIP flexion and active plantar flexion (intrinsic function and FDL function). Subjective results show an overall satisfaction rate of 89.5%, 98% for cosmetic results and 81% for pain relief. Estimated objective correction was 89.5% (Figs. 7 and 8). It is important to note that only 7/57 (12%) toes were stiff (rigid PIP with no passive flexion) and 86% of the toes had preserved active plantar flexion.
The rate of complications was 5.2%, all of them were minor and had no long term effect. There were 2 anatomical failures (3.5%) resulting in two cases of revision surgery by interphalangeal arthrodesis. There were no septic complications, trophic disturbances or complex regional pain syndrome.

5. Discussion

Selective tenotomy of the FDB, plantar capsulotomy for PIP release and PP osteotomy resulted in successful morphological correction of the second toe in 89.5% and 89.5% overall satisfaction.
including procedures with associated first ray surgery, whose correction provided permanent repair of the second toe.

Our results are similar to those in the literature for open surgery, which report satisfaction in between 80 and 90% of cases [1–10].

The percutaneous series in 50 patients by Debarge et al. [20] associating metatarsal osteotomies and FDB and FDL tenotomies reported 82% satisfaction after a mean follow-up of 11.6 months. The main limitation was the loss of active plantar flexion associated with complete resection of the FDB and FDL leaving only the lumbrical and interosseous muscles for plantar flexion.

The goal of our technique was to obtain both morphological correction and to preserve active plantar flexion by preserving the FDL, which was successful in 86% of patients. Our results with postoperative stiffness in only 12% of patients (7/57 feet) can be explained in part by the percutaneous technique but also and especially by the active participation of the patient in at home physical therapy exercises. The series included fixed deformities in nearly 75% of the cases, which did not prevent correction thanks to PIP release.

This preserved flexibility is a real advantage compared to traditional techniques which often result in stiffness, in particular arthroplastic resections [4,5] and interphalangeal arthrodesis [6,7], which even if they allow intrinsic FDL activity, can result in secondary distal interphalangeal flexion disturbances.

The disadvantage of this procedure is 6 weeks of mandatory immobilization to maintain toe correction and that requires a medical team (surgeon, nurse, podiatrist).

6. Conclusion

The percutaneous technique of selective tenotomy of the FDB, plantar capsulotomy for PIP release and osteotomy of the PP is a therapeutic option that provides effective realignment of PIP plantar flexion deformities of the second toe, while preserving passive and active plantar flexion with good intermediate term results and a low rate of complications. It can be proposed for a flexible or stiff toe in the absence of severe osteoarthritis with osteophytes. These initial results are encouraging but other clinical studies are needed to obtain a long-term evaluation of this percutaneous technique for correction of lesser toe deformities.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


