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Technical Tips

# Extensive lesser toes plantar plate tears reconstruction: A novel surgical technique with short-term clinical observations

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## Abstract

Extensive lesser toes plantar plate tears still challenge surgeons, as primary repair is not feasible. Reconstructive procedures used in these cases are often associated with stiffness, persistence of discomfort, floating toe, vascular compromise, and amputation. We describe a new technique, based on the concept of synthetic neoligamentplasty, in which synthetic tape and absorbable screws are used to achieve metatarsophalangeal joint stabilization in extensive tears (grade IV).

**Level of evidence IV.**

**Keywords:** Plantar plate; Toes; Metatarsophalangeal joint.

## Introduction

The plantar plate is a fibrocartilaginous structure that plays a fundamental role in the sagittal stability of the metatarsophalangeal joint (MTPJ)[1]. Traumatic and degenerative lesions of the plantar plate have the potential to cause instability, swelling, pain, and deformity of the lesser toes. The second MTPJ is by far the most affected, and frequently a disinsertion of the lateral phalangeal aspect of the plantar plate occurs[2]. After analyzing cadavers with "crossover" deformity, Coughlin et al.[3] developed a grading system based on the severity of the plantar plate lesions as shown in Figure 1.

The aim of this grading system is to help surgeons build their strategy for treating plantar plate tears. Nonetheless, extensive plantar plate tears (grade IV) are still challenging surgeons, as primary repair is not feasible; a demanding reconstructive procedure is often necessary, such as flexor-to-extensor tendon transfer, proximal phalangeal resection, syndactilization, and even toe amputation. Unfortunately, these types of surgery can be associated with stiffness, persistent discomfort, a floating toe, and vascular compromise.

The objective of this study is to demonstrate a new reconstruction surgical technique to address grade IV lesser toe instability using a synthetic neoligamentplasty concept, where synthetic tape and absorbable screws are used with the specific purpose of filling the existing gap in the medical literature about efficient and safe resources for the treatment of severe instability of the MTPJ of the lesser toes. To our knowledge, this is the first reported application of a synthetic neoligamentplasty configuration for grade IV plantar plate tears using dual oblique FiberTape fixation.

## Methods

### Study design

This study is a technical note with short-term clinical observations. Four patients (five toes) with grade IV plantar plate tears and severe MTPJ instability that failed conservative

Study performed at the Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.

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treatment and refused alternative procedures underwent the described technique between 2016 and 2020 and were followed for a minimum of two years. All patients provided consent to the procedure. Procedures were performed by two experienced foot and ankle surgeons. Although no outcome measure was utilized, the surgeon's subjective perception was noted.

## Surgical technique

The MTPJ can be exposed through a midline dorsal longitudinal approach or a long, italic "S" shaped incision.

Collateral ligaments are sectioned to allow optimal visualization of the inferior border of the proximal phalanx and the plantar portion of the metatarsal head.

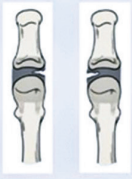
| Grade | Clinical Findings | Surgical Findings |
|---|---|---|
| Zero | MTPJ pain and swelling<br>Reduced Toe Purchase<br>Negative MTP Drawer Test<br>MTP joint well aligned<br>No toe deformity |  |
| One | MTPJ Pain / mild swelling<br>Loss of Toe Purchase<br>Mild MTP Drawer Test (<50%)<br>MTPJ mild malalignment<br>Widening web space<br>Toe Medial Deviation |  |
| Two | MTPJ pain / Reduced swelling<br>No Toe Purchase<br>Moderate MTP Drawer Test (>50%)<br>MTPJ Moderate malalignment<br>Medial, Lateral, Dorsal Deformity<br>Hyperextension of the toe |  |
| Three | MTPJ pain / Reduced swelling<br>No Toe Purchase<br>Very Positive MTPJ Drawer Test<br>Flexible Hammertoe<br>MTPJ severe malalignment<br>Cross-over toe<br>Flexible Hammertoe |  |
| Four | MTPJ and toe pain / No swelling<br>No toe purchase<br>Dislocated MTPJ<br>Fixed Hammertoe<br>MTPJ severe deformity<br>Dorsomedial Toe dislocation |  |

**Figure 1.** Five degrees of severity grading system for the plantar plate lesions according to Coughlin et al.[3]

Using a 2.5 mm diameter drill bit, two bone tunnels are created at the base of the proximal phalanx. Both medial and lateral tunnels are directed in a light oblique fashion from a distal-dorsal entry point to a proximal, justa-articular plantar exit. Two new oblique dorsal-plantar bone tunnels—medial and lateral—are made at the distal metaphyseal metatarsal area (Figure 2A).

The exits of both tunnels must be cautiously positioned not to jeopardize the articular surface of the metatarsal head (Figure 2A). A #2 FiberTape (Arthrex Inc., Naples, FL, USA) is passed through the bone tunnels, guided by a nitinol wire, to create a mesh for the plantar stabilization of the MTPJ. It enters the dorsal aspect of both proximal phalanx tunnels, exiting in the plantar aspects of both orifices (Figure 2B).

Then, both FiberTapes' limbs are driven, with the help of a nitinol loop, through the plantar orifices of corresponding sides of the metatarsal bone tunnels, exiting in its dorsal aspect (Figure 2C, D). One of the limbs of the tape is passed from dorsal to plantar through the other metatarsal orifice (Figure 2E, F). Both limbs are tensioned, and the toe should be kept at a neutral sagittal position (flexion-extension).

With adequate tensioning and positioning, fixation is made with a 3 x 8 mm BioTenodesisâ screw (Arthrex Inc, Naples, FL, USA) (Figure 2G, H, I).

Before closing the skin, the medial and lateral collateral ligaments (proper and accessory), as well as the articular capsule and the extensor hood, are sutured to add complementary stabilization to the joint. It is also important to remove the tourniquet and achieve thorough hemostasis. Figure 3 shows preoperative (A) and postoperative (B) clinical and radiographic images. Figure 4 demonstrates some surgical steps of the procedure.

Postoperatively, no weight-bearing is allowed for two weeks. Partial weight-bearing with a stiff-sole shoe is allowed after this period, progressing to full weight-bearing throughout the week. The stiff-soled shoe is continued for six weeks.

Little plantar flexion mobilization is stimulated two weeks after surgery, and active flexion after three weeks.

After this period, the patient is encouraged to wear stable low-heeled shoes until completing six months postoperatively.

Although the objective of this study is to present the surgical technique, we consider it worthwhile to report the results of the first four patients treated with this system to broaden understanding of the method. At the midterm (24 months minimum) follow-up, all of them showed improvements in pain, return to daily activities, and toe alignment. On the other hand, a small degree of dorsal subluxation was still observed on clinical examination and radiographs.

## Discussion

Over the last two decades, orthopedic comprehension of plantar plate anatomy, pathophysiology, and treatment has evolved. The MTP instability may be treated with conservative measures such as immobilization and non-steroidal anti-

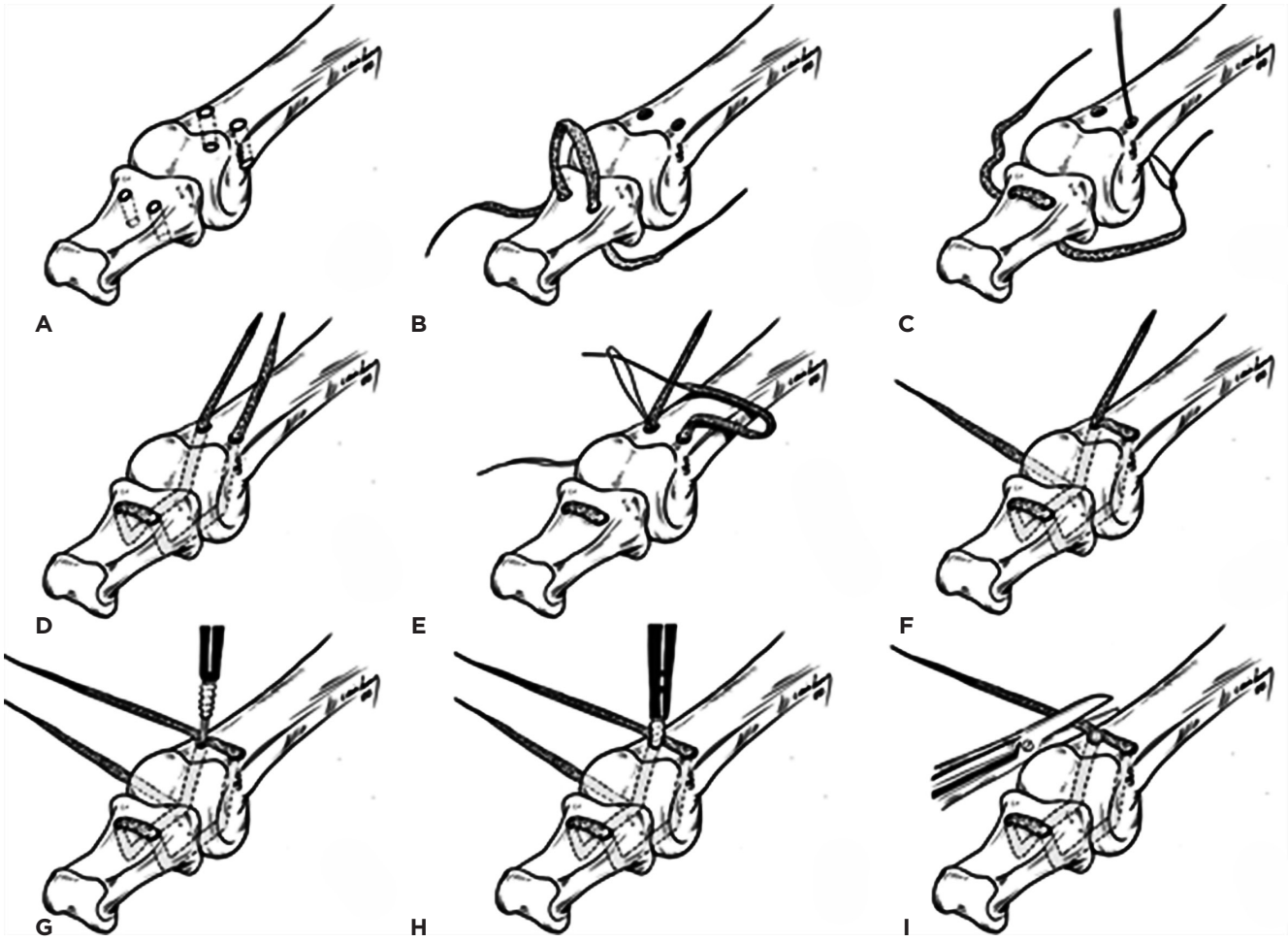



**Figure 2.** Surgical Technique (A) Bone holes at proximal phalanx and metatarsal neck; (B) A #2 FiberTape is passed, from dorsal to plantar, through the phalangeal tunnels; (C-D) with the help of a nitinol wire loop, both limbs of the FiberTape are driven, from plantar to dorsal, through the metatarsal neck tunnels; (E-F) The same nitinol wire loop is used to pass one of the FiberTape limbs through the opposite metatarsal neck bone tunnel; (G-H) After the appropriate tensioning of the tape, a 3 x 8 mm Biotenodesis screw is introduced in the bone tunnel that hold both limbs of the tape, to stabilize the construct; (I) The tape arms are cut flush to the bone.


**Figure 3.** Clinical and radiographic images of a patient with hallux valgus deformity combined with a second metatarsophalangeal plantar plate grade IV tear. (A) Preoperative (B) Postoperative.

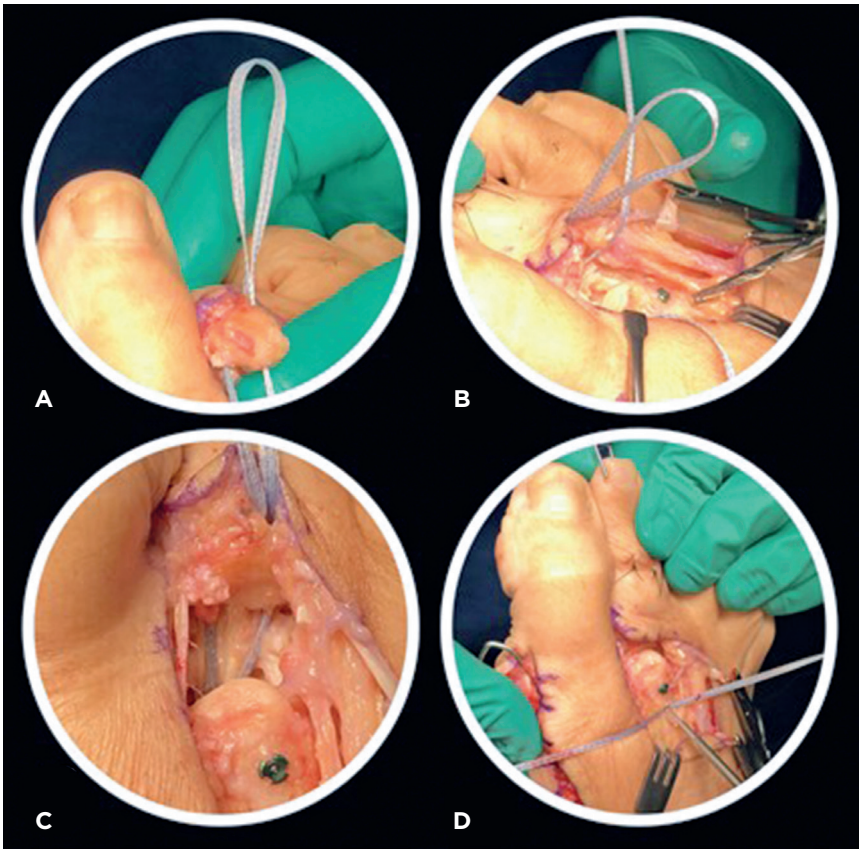



**Figure 4.** Intraoperative images of the technique (A) Folded #2 FiberTape is passed through the phalangeal bone holes from dorsal to plantar; (B) Metatarsal bone holes being made; (C) Two-limb fashion FiberTape configuration; (D) Biotenodesis screw stabilizing the construct.

inflammatory drugs (NSAIDs) with expected pain and synovitis relief, even though obtaining an adequate alignment is unlikely to occur[3].

Until recently, surgical options for plantar plate tears were limited to synovectomy, tendon transfers, and osseous decompressions[3]. Fortunately, recent studies have provided orthopedic surgeons with a new perspective on the role of repair in treating plantar plate tears, using different types of sutures and incisions[4].

Comparing primary plantar plate repair, flexor-to-extensor tendon transfer, and both procedures combined, Ford et al.[5] concluded that primary repair of the plantar plate is a viable alternative to tendon transfer in stabilizing the lesser MTPJ. Bouché et al.[6] described a combined plantar plate and hammertoe repair with flexor digitorum longus (FDL) tendon transfer via a plantar incision. Powless et al.[7] used both dorsal and plantar incisions to address plantar plate tears and had good results. Flint et al.[8] prospectively followed 97 patients (a total of 138 plantar plate tears) treated with plantar plate repair utilizing the Complete Plantar Plate Repair System (CPR, Arthrex, Naples, FL, USA) and noticed an overall improvement in AOFAS and pain at one-year follow-up. In a prospective study in which 40 graded I, II, and III plantar plate tears were treated through the combination of the direct plantar plate repair, capsular and collateral ligaments reefing with a Weil osteotomy, Nery et al.[4] reported the AOFAS score improvement in 77% of the patients, obtaining an average AOFAS forefoot score of 92 points. Interestingly, the authors demonstrated that outcomes were worse at the highest grades of instability and tears, indicating the progressive nature of these lesions.

Treatment for more severe plantar plate tears (grade IV), where there is a combination of transversal and longitudinal tears, continues to be a challenge. To overcome the impossibility of repair, many alternative measures have been proposed, including flexor-to-extensor tendon transfer[5], arthroplasty resection[9], proximal phalangeal resection[10-12], syndactylization[10,11], arthrodesis[13], and even toe amputation[14,15]. Some studies have demonstrated good results with flexor-to-extensor tendon transfer, but most have not correlated outcomes with the clinical and anatomical preoperative grade of the plantar plate tear[16,17]. This is

probably the most commonly used procedure for grade IV plantar plate tears and is intended to convert a deforming force into a stabilizing mechanism to compensate for intrinsic musculature dysfunction. Multiple techniques have been described, including passing two sleeves of the FDL around the phalanx via 1, 2, or 3 incisions or transferring the FDL tendon from plantar to dorsal through a bone tunnel at the proximal phalanx. Nery et al. [4] reported results in a cohort of 17 grade IV plantar plate tears treated with the classic combination of a distal Weil osteotomy and flexor-to-extensor tendon transfer, with a mean follow-up of 12 months. A 46.3-point improvement in the AOFAS score was achieved, with increased MTPJ stability observed in all patients. Thompson et al. [17], in a series of 13 patients who underwent flexion-to-extension to treat second MTPJ instability, found that five patients still had mild discomfort and 11 had passive dorsiflexion of 30 degrees or less, demonstrating the stiffness inherent in this procedure. Myerson and Jung[18] reported that 34% of patients had either major reservations or were dissatisfied with the outcome of the flexor-to-extensor tendon transfer. Extensor tendons (brevis and longus) transfers have been used as an alternative to flexor-to-extensor transfers with comparable results. Barca and Acciaro[19] used EDL tendon transfer to treat crossover deformities, achieving an 83% patient satisfaction rate. On the other hand, alternatives to tendon transfer are associated with suboptimal results. Conklin and Smith[13] reported a 29% rate of dissatisfaction among patients undergoing basilar resection of the proximal phalanx, with shortening of the toe as the most common complaint. In a short follow-up of patients who underwent hemiphalenctomy and syndactylization, Feeney et al.[20] reported an 18% persistence of moderate-to-severe malalignment, and one-third would not undergo the procedure again.

Recently, Sung[21] described a technique as an alternative to flexor tendon transfer in the presence of gross lesser MTPJ ligament instability, especially when the plantar plate has been completely torn or absent, using two 3.5 mm Swive-Lock Suture Anchors and a 2-mm-wide, 7-in.-long FiberTape. No results were described.

We believe that the technique described in this article could provide greater stability than the previously described technique because of its multiaxial configuration, using FiberTape in a two-limb fashion, without limiting MTF joint extension. Compared with flexor-to-extensor transfer, the use of a synthetic neoligamentplasty concept may reduce serious complications, such as vascular bundle constriction, that can arise when the FDL limbs are passed around the phalanx, particularly in patients with a history of prior procedures. More recently, percutaneous techniques have gained space, and initial results suggest that minimally invasive tenotomies and osteotomies can improve clinical outcomes in a dislocated second toe[22].

The most important limitations of this study are the lack of knowledge about potential damage to the joint cartilage of the metatarsal heads caused by friction or by the simple presence of synthetic tapes within the joints, and the absence of biomechanical cadaveric studies to confirm the efficacy of this joint-stabilizing method. Also, there is concern that symptomatic scarring and rigidity can occur secondary to the synthetic tape. If so, the surgeon should consider releasing the tape. Another limitation is the requirement that patients present with narrow metatarsals, as the technique requires four bone tunnels. Regarding the use of synthetic tapes in small joints, clinical and biomechanical studies have supported their use for first carpometacarpal joint and MTPJ instability, suggesting greater load-to-failure and faster same-level return-to-play recovery[23,24]. Prospective clinical trials are needed to support our hypothesis that this technique can improve outcomes in grade IV lesser toe instability.

## Conclusion

Synthetic neoligamentplasty using FiberTape and bioabsorbable screws offers a feasible reconstructive option for grade IV lesser MTPJ instability when native plantar plate repair is not feasible. Early results suggest restoration of alignment and pain relief with preservation of joint motion. Further biomechanical and long-term clinical studies are needed to validate these findings.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: RV *(https://orcid.org/0000-0002-4563-5726) Conceived and planned the activities that led to the study, participated in the review process, data collection; MP *(https://orcid.org/0000-0003-0325-8050), DB *(https://orcid.org/0000-0001-5404-2132), and CN *(https://orcid.org/0000-0002-9286-1750) Conceived and planned the activities that led to the study, participated in the review process, data collection, and performed the surgeries. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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