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The success rate of first metatarsophalangeal joint lateral soft tissue release through a medial transarticular approach: A cadaveric study

Cesar de Cesar Netto[a,b,*], Lauren E. Roberts[b], Parke William Hudson[a], Brent Cone[a], Bahman Sahranavard[a], Ibukunoluwa Araoye[a], Ashish Shah[b]

[a] Department of Orthopaedic Surgery, University of Alabama at Birmingham, Birmingham, AL, USA
[b] Department of Orthopaedics, Foot and Ankle, Hospital for Special Surgery, New York, NY, USA

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ABSTRACT

Background: The objective of this study was to evaluate the success rate of first metatarsophalangeal joint (MTPJ) lateral soft tissue release through a medial transarticular approach.
Methods: Ten cadaveric specimens were used (6 females/4 males, mean age, 73.4 years). Lateral release was performed through a 4 cm medial approach using a number 15 blade. Surgical aim was to release four specific structures: lateral capsule, lateral collateral ligament (LCL), adductor hallucis tendon (AHT) and lateral metatarsosesamoid suspensory ligament (LMSL). Once completed, a dissection of the first intermetatarsal space was performed. Success rate was graded in accordance to the number of structures successfully released: 0% (no structures), 25% (1/4), 50% (2/4), 75% (3/4) and 100% (4/4). Inadvertent injuries to other soft tissue structures were recorded.
Results: The success rate for lateral soft tissue release was 100% in 7 cadaveric specimens, and respectively 75%, 50% and 25% in the other 3 specimens. The LCL was successfully released in all specimens. The lateral joint capsule, AHT and LMSL were released in 80% of the specimens. Chondral damage to the first metatarsal head, unintended release of the conjoined tendon and lateral head of the flexor hallucis brevis (FHB) occurred respectively in 40%, 50% and 20% of the specimens.
Conclusions: Our cadaveric study demonstrated high success rate in the release of specific lateral soft tissue structures of the first MTPJ through a medial transarticular approach. Inadvertent release of the lateral head of the FHB, conjoined tendon and iatrogenic chondral damage of the first metatarsal head are complications to be considered.
Level of evidence: Cadaveric study — Level V.

1. Introduction

Since it was first reported by Silver in 1923, the muscular imbalances and contracted tissue about the first metatarsophalangeal joint (MTPJ) continue to play an important role in the hallux valgus deformity [1–3]. Different techniques for surgical correction of hallux valgus have been described and the best clinical outcomes have been associated with a combination of both a bone alignment correction as well as a soft tissue release [4–7]. The distal soft tissue component of these corrections typically involves the sectioning of multiple contracted anatomical structures such as the lateral capsule and lateral collateral ligament (LCL) of the first MTPJ, adductor hallucis tendon (AHT) and the lateral metatarsosesamoid ligament (LMSL). This lateral release is then combined with tightening of the medial capsule to balance the corrected alignment at the level of the MTPJ [8,9].

Disagreement continues to exist within the literature regarding which of these various structures truly need to be released for adequate clinical results [10,11]. Schneider et al. in a cadaveric, radiographic, experimental study, evaluated the effect of a sequential release of the lateral MTPJ soft tissue structures on the correction of hallux valgus angle, 1-2 intermetatarsal angle and sesamoid subluxation. The authors emphasized the importance of the release of the first MTPJ lateral capsule, LCL and LMSL specifically in the correction of the deformity, but found that the release of the deep transverse metatarsal ligament (DTML) and the AHT did not contribute significantly to the amount of hallux valgus correction [12].

The surgical approach used to achieve proper visualization and safe release of the described structures is also a subject of controversy. Options include the traditional open dorsolateral

* Corresponding author at: Hospital for Special Surgery, 523 East 72nd Street, New York, NY 10023, USA.
E-mail address: cesardecesarnetto@gmail.com (C. de Cesar Netto).

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approach in the first intermetatarsal space, as initially describe by McBride [8], a medial transarticular aproach [13–17], a transmetatarsal approach [18], a dorsal flap over the first metatarsal through a medial approach [19], percutaneous minimally invasive [20], and arthroscopic techniques [21,22]. The clinical and radiographic outcomes of lateral soft tissue release in patients with hallux valgus are reported to be similar with either a dorsal or medial transarticular approach [4,23].

Benefits of using the dorsolateral open first webspace approach include the possibility of direct visualization of the lateral structures and the possibility of a more accurate, controlled and selective release. However, this approach requires a second incision which prolongs the surgical time and introduces the possible development of an unsightly or symptomatic scar within the first webspace [4]. Depending on the associated procedures required and extent of the medial dissection, the use of an additional lateral approach may also lead to an increased risk of injury to the blood supply of the head specifically the principle and nutrient artery of the first metatarsal which is usually a branch of the first dorsal metatarsal artery [24,25]. Conversely, the medial transarticular approach offers presumed decreased morbidity and cosmetic advantage by avoiding an additional incision, reducing the risk of iatrogenic injury to the lateral vascular structures and osteonecrosis of the metatarsal head, but does poses a potential increased risk of intraarticular cartilage injury, specially of the head of the first metatarsal as well as the possibility of inadvertent release of the flexor hallucis brevis tendon [14,26].

Despite the proposed benefits this approach, there is often a concern that the medial transarticular release itself may be inadequate, especially if one wishes to surgically release the adductor hallucis conjoined tendon specifically [26]. In the hallux valgus deformity, the lateral and dorsal positioning of the hallucal-sesamoid complex makes this particular release more challenging to be fully and precisely accomplished through a medial approach [25].

The objective of our study was to further assess the anatomical success rate and safety of a lateral soft tissue release of the 1st MTPJ when performed through a medial transarticular approach. Our hypothesis was that selective release of targeted structures would be reliably achieved, with a low rate of inadvertent injuries.

2. Material and methods

Ten below-knee thawed fresh-frozen cadaveric specimens were used, including 6 females and 4 males, with a mean age of 73 (range, 53–90) years. None of the specimens had gross deformity of the forefoot or any radiographic evidence of degenerative changes of the first MTPJ. All surgical procedures were performed by the same fellowship-trained orthopaedic foot and ankle surgeon, following the same standardized surgical approach and sequential soft tissue release. Using a no. 15 scalpel blade attached to a no. 3 scalpel handle, a 4 cm incision was made medially, centered over the first MTPJ, at the junction of the glaborous and dorsal skin with care to avoid the dorsal medial hallucal nerve. Dissection was carried deep to the first MTPJ capsular plane. A longitudinal capsulotomy was then made, in line with the skin incision. The capsule was partially detached proximally off the metatarsal head and distally off the base of the proximal phalanx, avoiding extensive dissection over the dorsal and lateral aspect of the metatarsal head. The joint was inspected to rule out any pre-existing osteochondral injury. The medial eminence of the first metatarsal head was resected with a n° 38 sagittal saw, with a starting point about 2 mm medial to the sagittal sulcus.

The surgical aim for the lateral soft tissue procedure was to release the specific structures that were found to significantly influence radiographic correction of hallux valgus parameters in a cadaveric study by Schneider in 2012 [12].

The first two structures released were the lateral aspect of the first MTPJ capsule and the LCL. To do so, manual axial traction was applied in the first toe and a no. 15 blade was inserted into the first MTPJ with care to avoid the cartilage surface. The lateral capsule and LCL were sectioned in a plantar to dorsal direction, aiming to avoid injury to plantar structures including the insertion of the lateral short sesamophalangeal ligament or conjoined tendon of the AHT and FHB into the proximal phalanx of the first toe. This initial release provided increased laxity and space in the first MTP joint, especially in a cadaveric specimen, allowing for easier access and direct visualization of the additional structures to be sectioned.

Using a freer elevator, the lateral sesamoid was then localized and retracted into a plantar direction. Under direct visualization, a longitudinal cut was then performed, from proximal to distal, in between the lateral sesamoid and the head of the first metatarsal, releasing the third aimed structure, the lateral metatarsosesamoid suspensory ligament. The sectioning of this ligament led to improved visualization of the lateral sesamoid.

Without any further dissection, the scalpel was then kept underneath the first metatarsal head, with its blade facing dorsally. While keeping a manual varus stress applied to the first toe, an indirect release of the fourth aimed structure, the insertion of the AHT into the proximal and lateral aspect of the lateral sesamoid was performed. The section was made from medial to lateral in an attempt to avoid inadvertent sectioning of the lateral head of the flexor hallucis brevis tendon into the proximal aspect of the lateral sesamoid. Some of the surgical steps are illustrated in Fig. 1.

Once the transarticular release was completed, a manual varus stress was applied to the first toe and a second 4 cm incision was then made over the dorsal aspect of the first intermetatarsal webspace. A layered and careful dissection was then performed, allowing adequate evaluation of the anatomical structures in the first intermetatarsal space (Fig. 2). Assessment was made of the adequacy of release for the four aimed soft tissue structures: lateral first MTPJ capsule, LCL, LMSL and AHT. Simple descriptive statistical analysis was used to describe the success rate (%) in the release of the four aimed soft tissue structures: 0% (no structures), 25% (1/4), 50% (2/4), 75% (3/4) and 100% (4/4). Inadvertent injuries to other soft tissue structures, including the FHB insertion in the proximal aspect of the lateral sesamoid, the insertion of the conjoined tendon of the AHT and FHB into the proximal phalanx, flexor hallucis longus (FHL) tendon, first intermetatarsal neurovascular bundle, and the articular cartilage of both first metatarsal head and proximal phalanx were also recorded.

3. Results

A summary of the structures successfully released and inadvertent injuries is presented in Table 1. All four targeted soft tissue structures were successfully released (100% success rate) in seven of the ten cadaveric specimens (70%). Three out of four targeted structures were successfully released (75% success rate) in one cadaver, while two of the four and one of the four targeted structures were successfully released in the other two specimens (50% and 25% success rates, respectively). The LCL was successfully released in all cadaveric specimens (10/10, 100%). The lateral joint capsule, AHT, and LMSL were completely released in eight out of the ten specimens (80%). Inadvertent superficial abrasion or cutting injuries to the chondral surface of the first metatarsal head occurred in four out of ten cadaveric specimens (40%). Unintended injury to the insertion of the lateral head of the FHB tendon into the

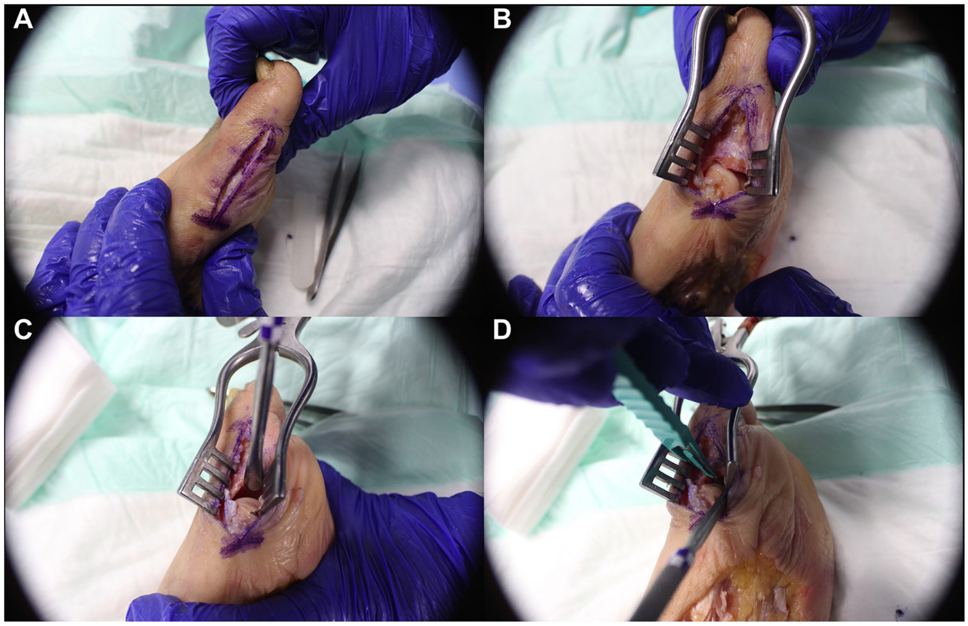

Fig. 1. Medial approach to the 1st metatarsophalangeal joint (MTPJ) (A). Longitudinal capsulotomy was performed exposing the head of the 1st metatarsal, proximal phalanx and 1st MTPJ (B). Using a freer elevator the lateral capsule and lateral collateral ligament (LCL), lateral sesamoid and lateral sesamoid-phalangeal ligament were assessed (C). With a no. 15 scalpel blade attached to a no. 3 scalpel handle, the structures were released (D).

proximal aspect of the lateral sesamoid occurred in two out ten cadavers (20%). Inadvertent injury with partial release of the conjoined tendon (AHT and FHB) into the proximal phalanx happened in five out of ten specimens (50%) (Fig. 3). No injuries to the FHL tendon, neurovascular bundle, DTML or articular surface of the proximal phalanx were noted.

4. Discussion

The only medial supporting structures of the first MTPJ are the abductor hallucis, medial collateral ligament and the medial sesamoid [27]. During the progressive development of hallux valgus deformity, once the medial restraints start to fail, the

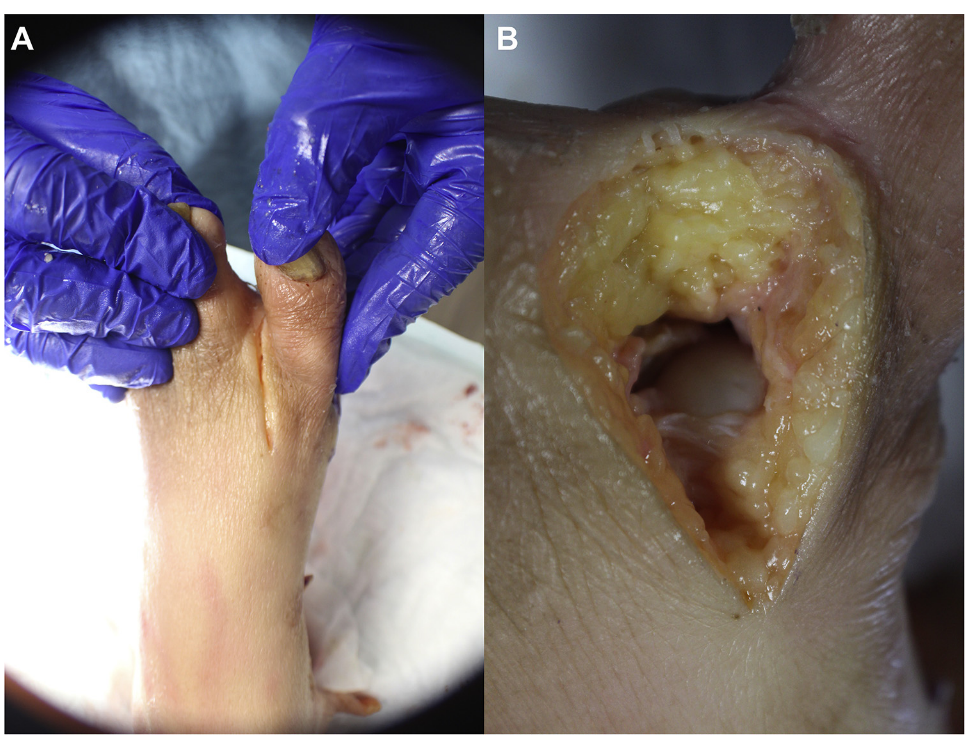

Fig. 2. Dorsolateral approach over the 1st intermetatarsal space (A). Exposure of the anatomical structures of the lateral aspect of the first metatarsophalangeal joint (MTPJ) (B).

Table 1
Summary of the structures successfully released, inadvertent injuries and accuracy in the release of the four targeted structures.

Cadaveric specimen	Lateral collateral ligament	Lateral 1st metatarsophalangeal joint capsule	Adductor hallucis tendon	Lateral metatarsosesamoid suspensory ligament	1st metatarsal head chondral damage	Inadvertent release of the conjoined tendon	Inadvertent release release of the lateral head of the flexor hallucis brevis	Accuracy in the release of the four aimed structures
1	Successful	Not successful	Successful	Not successful	Yes	Yes	No	2/4 (50%)
2	Successful	Successful	Successful	Successful	No	No	No	4/4 (100%)
3	Successful	Successful	Successful	Successful	Yes	Yes	No	4/4 (100%)
4	Successful	Successful	Successful	Successful	No	Yes	Yes	4/4 (100%)
5	Successful	Successful	Successful	Successful	No	Yes	No	4/4 (100%)
6	Successful	Successful	Successful	Successful	No	No	No	4/4 (100%)
7	Successful	Successful	Not Successful	Successful	Yes	No	Yes	3/4 (75%)
8	Successful	Successful	Successful	Successful	No	No	No	4/4 (100%)
9	Successful	Not successful	Not successful	Not successful	Yes	No	No	2/4 (50%)
10	Successful	Successful	Successful	Successful	No	Yes	No	4/4 (100%)
	10/10 (100%)	8/10 (80%)	8/10 (80%)	8/10 (80%)	4/10 (40%)	5/10 (50%)	2/10 (20%)	

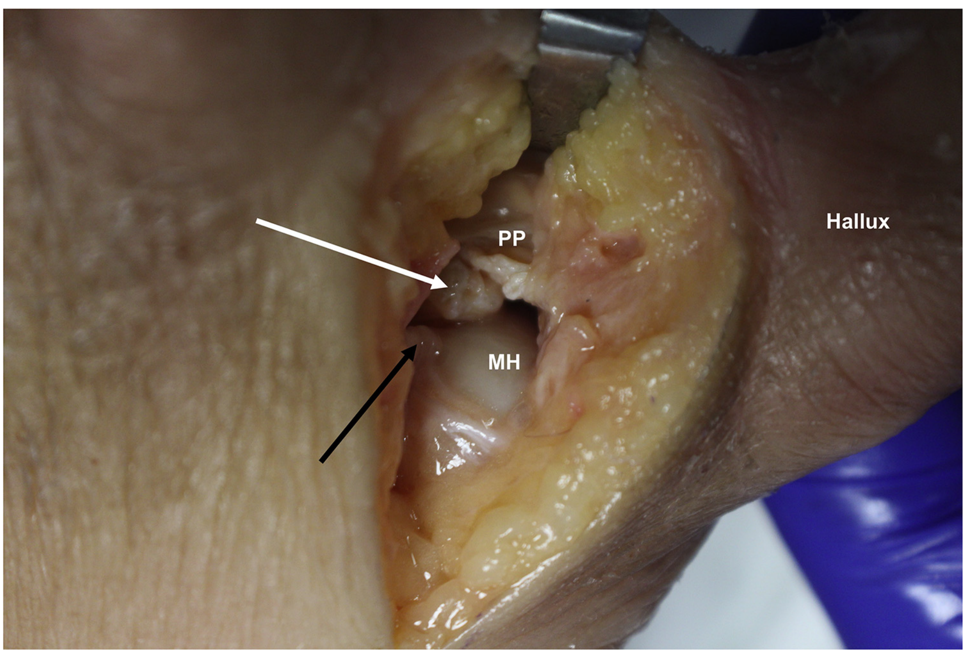

Fig. 3. Example of successful release of the lateral capsule and lateral collateral ligament (LCL) attached to the metatarsal head (MH) (black arrow) and inadvertent release of the conjoined tendon (white arrow) into the proximal phalanx (PP).

metatarsal head can deviate medially, leaving the static lateral sesamoid and ligamentous complex in a relative lateral position, attached to the proximal phalanx and adductor hallucis muscle. With the progressive medial and plantar deviation of the first metatarsal head, muscles that cross the first MTPJ and normally help in maintaining the positioning of the first toe lose their control capability and become dynamic deforming forces [2].

The real effectiveness of lateral soft tissue release in the success of deformity correction and improved clinical results is still debatable. Even though the combination of both osseous and distal soft tissue procedures has been shown to provide overall good to excellent clinical results [5,6,10,11,25,28–30], different reports demonstrated little influence of the lateral soft tissue in the outcomes of surgical correction, specially in mild to moderate deformities [7,31,32].

In the scenario where the release of contracted lateral soft tissue structures of the first MTPJ is considered important for a complete surgical treatment of hallux valgus deformity, controversy still remains regarding which exact structures need to be released for adequate surgical correction.

Schneider in a study with 15 cadaveric specimens with hallux valgus deformity, evaluated the degree of radiographic correction of the first MTPJ angle, first intermetatarsal angle, and sesamoid subluxation grade following three different sequential release lateral soft tissue structures that included: AHT, LCL, LMSL, lateral short sesamophalangeal ligament, DTML, and plantar capsular attachment. The authors reported similar final deformity correction independently of the order the structures were released. They also found that, when associated with a medial capsular reefing, the release of the lateral 1st MTPJ capsule and LCL had some influence but the sectioning of the LMSL represented the key step for successful lateral release and hallux valgus deformity correction in all three different sectioning sequences used. The authors emphasized that the transection of the DTML and AHT had almost no corrective effect and that the release of the lateral short sesamophalangeal ligament, in our study referred as conjoined tendon, and the plantar attachment of the lateral articular capsule should be prevented, with increased risk of overcorrection and 1st MTP joint instability [12].

Owens and Thordarson highlighted the importance of proper release of the AHT and described the anatomy of the AHT inserting in lateral sesamoid. They also detailed the conjoined insertion of the AHT and lateral head of the FHB, highlighting the increased risk of subsequent development of dynamic varus deformity of the great toe when this structure is released from the plantar and lateral aspect of the proximal phalanx [33].

The best surgical approach for the release of the lateral soft tissue structures of the 1st MTPJ is also a subject of controversy. The use of the more traditional dorsolateral approach over the 1st intermetatarsal space provides some benefits that include the direct visualization of the structures to be released, hypothetically increasing the success rate of the procedure. However, it requires a second incision and more extensive dissection that can increase the risk of injury to the first dorsal metatarsal artery and the vascular supply to the head of the 1st metatarsal head [24], and the chances for a symptomatic dorsal scar [4]. On the other hand, the medial transarticular avoids the necessity of an additional incision, decreases the risk of injury to the vascular supply of the 1st metatarsal head but provides limited visualization of the lateral structures, with potential inadequate release of the soft tissue structures [26]. It also poses increased risk of intraarticular cartilage injury and inadvertent release of the conjoined tendon from the proximal phalanx and FHB from the lateral sesamoid flexor halluces brevis tendon injury [14]. Clinical studies have demonstrated similar clinical results in regards to deformity correction with both dorsolateral and medial transarticular approaches [4,23].

Limited anatomic studies evaluating the success and inadvertent injuries associated with the medial transarticular approach have been performed. Lin et al., in a study with 12 specimens with no hallux valgus deformity, compared the standard first dorsolateral approach to the medial transarticular approach. They aimed to release the lateral capsule of the 1st MTPJ, LCL, LMSL, AHT (both transverse and oblique heads), and the conjoined tendon from the base of the proximal phalanx. The authors were able to achieve adequate release of the lateral joint capsule, LCL and LMSL in all six specimens that underwent medial transarticular approach, conjoined tendon in 4 out 6 specimens (66%) but failed to release the insertion of the AHT into the lateral sesamoid in all specimens (6/6, 100%). The medial transarticular approach was also associated with inadvertent injury to articular cartilage of the 1st metatarsal head and FHB tendon in 3 out 6 cadaveric specimens (50%) [26].

Stamatis et al. evaluated the success of the medial transarticular approach in the release of the lateral 1st MTPJ soft tissue structures using a more flexible arthroscopic blade. Using 15 cadaveric specimens, four of them with moderate hallux valgus deformity, the authors aimed to release the lateral capsule, conjoined tendon, AHT and LMSL. They achieved complete release of the lateral capsule, LMSL and conjoined tendon from the base of the proximal phalanx in all specimens (100%). However, both heads composing the AHT were completely released in only five specimens (33%). Inadvertent injury to the lateral head of the FHB insertion in the lateral sesamoid occurred in five specimens (33%). No injuries to the first intermetatarsal neurovascular bundle and DTML were reported and only one specimen (7%) had inadvertent injury to the articular cartilage of the head of the 1st metatarsal. The results were similar in specimens with or without hallux valgus deformity [14].

In our study we precisely defined the structures aimed to be released and intended to preserve the insertion of the conjoined tendon of the FHB and AHT into the plantar and lateral aspect of the proximal phalanx, since its release was formerly associated with increased risk for development of hallux varus [12,33]. Differently from prior results, we had adequate release of the AHT in 80% (8/10) of the specimens, with similar success for sectioning of LCL (100%, 10/10), lateral capsule and LMSL (80%, 8/10). All four targeted structures were released in 70% of specimens.

With regards to complications, we had no cases of injury to the FHL tendon, intermetatarsal neurovascular bundle, DTML or proximal phalanx cartilage. However, we did have injuries to the 1st metatarsal head cartilage in 40% of cases. The frequency is slightly lower than the reported by Lin et al. when using a similar scalpel blade, but still considerably high. It might be explained by a combination of the cadaveric rigidity, limited intraarticular space in the 1st MTPJ and the use of a traditional no. 3 scalpel handle and a no. 15 blade. The short characteristic of the blade and the stiff and broad properties of the scalpel handle could potentially explain the occurrence of superficial abrasion and cutting injuries of the chondral surface of the first metatarsal head. We do believe that the use of thinner and longer scalpel handle, such as a Beaver blade or an arthroscopic blade, similar to the one used by Stamatis et al. [14], would potentially decrease the risk of inadvertent cartilaginous injuries of the 1st metatarsal head.

We had an important number (50%, 5/10) of unintended injury with partial release the conjoined tendon (AHT and FHB) from the proximal phalanx. This could represent one of the most important findings of the study. Because of the limited intraarticular space of the 1st MTPJ and the proximity of the plantar aspect of the lateral capsule the insertion of the conjoined tendon into the proximal phalanx, the release of one of them without injuring the other represents a challenge. Since the release of the lateral capsule and LCL were previously demonstrated to poorly contribute to the correction of hallux valgus deformity [12], avoiding any release at the level of the proximal phalanx should be considered to preserve the insertion of the conjoined tendon thus decreasing the risks of iatrogenic hallux varus.

We also had a 20% rate (2/10) of inadvertent injury to the insertion of the lateral head of the FHB into the lateral sesamoid, a number slightly lower than the one described by Stamatis et al. [14] These injuries probably most likely occurred during the release of AHT from the plantar and lateral aspect of the lateral sesamoid or during the release of the LMSL. Again, accordingly to Schneider et al, the release of the AHT could be avoided without significant changes in the results of the success of the lateral soft tissue release and correction of the hallux valgus deformity. However, the transection of the LMSL would still be mandatory [12].

There are multiple limitations to this study. First and most importantly, these cadavers did not have an existing hallux valgus deformity. For this reason, the extent of clinical correction based on which structures were specifically released could not be evaluated. Also, the release of soft tissue structures in feet with hallux valgus deformity is certainly more difficult as a result of the subsequent increased lateral position of the structures in question. Secondly, the cadaveric rigidity of the specimens could have influenced our results. In a real patient, with increased 1st MTPJ flexibility, the release of the aimed structures could be better facilitated, this especially applies to injuries to the articular cartilage of the 1st metatarsal head and conjoined tendon. Thirdly, we acknowledge that lateral release of the 1st MTPJ is a controversial topic and different techniques and outcomes are reported in the literature. Due to the cadaveric nature of our study, it is impossible to ascertain if a “successful” release in a cadaveric specimen would also represent a successful release in a real clinical situation. We believe it is important to emphasize that there is a thin line between adequate and excessive release, and its risk of hallux varus deformity. Finally, we had a limited number of cadaveric specimens. Increased sample size could have potentially improved the impact of this study.

In conclusion, our cadaveric anatomical study demonstrated a high success rate in the release of specific lateral soft tissue structures of the 1st MTPJ through a medial transarticular approach. Inadvertent release of the conjoined tendon, what can potentially increase the risk for hallux varus, and iatrogenic damage of the chondral surface of the 1st metatarsal head represent frequent complications. To avoid them, one should consider the use of a thinner and longer scalpel blade and releasing the lateral metatarsosesamoid suspensory ligament in isolation.

Conflict of interest

The author(s) received no financial support for the authorship, and/or publication of this article. Stryker paid for the cadaveric specimens used. There are no other conflicts of interest.

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