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Favorable change in patient-reported outcomes following peroneus longus to brevis tendon transfer and lateral ankle ligament reconstruction☆

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ABSTRACT

Background: A peroneus longus to brevis tendon transfer is recommended for a severely torn peroneus tendon, but there is little research on the outcome. We conducted a prospective cohort study to examine patient-reported outcomes after this procedure.
Methods: Thirty-two patients underwent a peroneus longus to brevis tendon transfer and lateral ankle ligament reconstruction, 11 had an additional calcaneal osteotomy. The Foot and Ankle Outcome Score (FAOS) and Short Form-36 (SF-36) were assessed preoperatively, six and 12 months after surgery.
Results: Preoperative mean FAOS was 51.7 (SD 17.8) compared with 72.7 (SD 21.2) at 12 months, an improvement of 21 (95 % CI 12.7–28.0) ($p < 0.0001$). SF-36 improved significantly in the three domains involving physical function and bodily pain ($p < 0.007$).
Conclusion: Patient-reported outcomes improved significantly through peroneus longus to brevis tendon transfer. This procedure is worth considering for patients with a severely damaged peroneus tendon.
Level of evidence: Level II: Prospective cohort study

1. Introduction

The peroneus brevis and longus tendons can be injured through ankle supination trauma or due to chronic lateral ankle instability [1–5]. Tears to the peroneus brevis tendon are three to six times more common than peroneus longus tears, and 20–40 % of cases involve both tendons [3,4,6,7]. Suture of the torn tendon has been reported to achieve good outcomes [6,8,9]. In more severe cases, a direct repair might not be possible, and peroneus longus to brevis tenodesis or tendon transfer has been suggested [2,4,10]. Few studies have examined the outcome of the latter type of surgery, and study groups have been of limited size [2,4,10]. It still remains uncertain whether the surgery improves patients' foot function and quality of life.

We conducted a prospective cohort study involving patients with peroneus tendon tears treated with a distal peroneus longus to brevis tendon transfer and lateral ligament reconstruction. This intervention has become a standard procedure at our clinic due to previous good clinical outcomes. We aimed to evaluate whether there was significant improvement in the Foot and Ankle Outcome Score (FAOS) and Short Form-36 (SF-36) after the surgery, with the hypothesis was that patients' self-reported outcomes would improve.

2. Methods

Ethical approval was obtained from the Swedish Ethical Review Authority in December 2015 (Reg. no. 2015/428). Patients referred to the Orthopaedic Clinic at Uppsala University Hospital were asked to participate in a prospective follow-up if they were planned for surgery, which might include a peroneus longus to brevis tendon transfer. Patient-reported measures (PROMs) using the foot-specific questionnaire FAOS [11] and the health questionnaire SF-36 [12,13], as well as clinical examination including an anterior drawer test of the ankle and a gait analysis (not reported in the present study),

☆ The study was registered in ClinicalTrials.gov in 2015 with the unique protocol ID 2015/428.

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Table 1
Study protocol.

	Preoperative	Postoperative 6 months	Postoperative 12 months
PROMs	X	X	X
Weight-bearing radiographs	X	X	
Hindfoot alignment view	X	X	
MRI	X		
Clinical examination	X	X	X

were conducted preoperatively and at six and 12 months postoperatively. Weight-bearing radiographs, including the hindfoot alignment view [14], were taken before surgery and six months postoperatively and examined by the first author and an experienced radiologist. Clinical examination in conjunction with an MRI was used to establish the preoperative diagnosis of peroneal tendon injury. Patients with any previous injury to their lower extremity or other diseases that might affect their gait and patients who could not complete the questionnaires for cognitive or language reasons were excluded. Patients with previous surgery on their lateral ligaments or suture of a tear in one of the peroneal tendons were retained in the study. The follow-up protocol can be found in Table 1. The preoperative examination and the surgery were performed by the first author (AES), while two other independent foot and ankle surgeons performed all follow-ups.

Surgery targeting restoration of peroneus brevis tendon function [10,15] was either a distal peroneus longus to brevis tendon transfer in case of a torn peroneus brevis, where the longus was transected in the cuboid tunnel, or a distal peroneus longus to brevis tendon transfer in cases of a distally torn peroneus longus tendon (Fig. 1). A tenodesis of the two tendons was performed proximal to the superior retinaculum before the irreparable tendon was excised. A lateral sliding calcaneal osteotomy was performed if the patient had developed a pathological varus hindfoot compared to the other side. A gastrocnemius recession was added if the Silfverskiöld's test was positive [16]. To avoid additional variation between the patients that might complicate future evaluation, all patients underwent lateral ligamental reconstruction using a modified Broström technique [17]. Two previous studies on patients undergoing primary repair of the peroneus brevis tendon have reported 44 % and 41 % lateral ankle instability, respectively [6,9]. In a previous study of peroneus longus to brevis transfer, 88 % of patients had a positive drawer test, indicating injuries to the lateral ligaments [15]. Thus, a decision was taken to reconstruct the lateral ligaments in all patients in the current study. After six weeks in plaster (eight weeks if a calcaneal osteotomy was performed) the patients underwent standardized rehabilitation (Supplements 1 and 2).

In February 2021, 50 consecutive and potentially eligible patients had been recruited to the study with written informed consent.

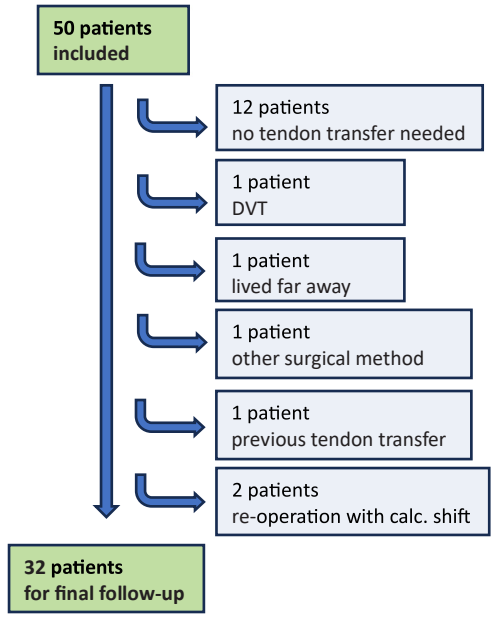

Fig. 2. Flowchart of the patients included in and excluded from the study.

Twelve patients were subsequently excluded because they did not meet the inclusion criteria and an additional six were excluded for other reasons (Fig. 2). The final cohort of 32 patients were then followed for 12 months.

2.1. Primary and secondary outcomes

The FAOS, which was first validated for ankle instability [11], was chosen as the primary outcome measure because symptoms of peroneal tendon tears are related to ankle instability [3,5,9], and because no outcome score has been validated for peroneal tendon injuries per se. The FAOS is divided into five patient-related dimensions: 1) other symptoms such as stiffness, swelling, and range of motion, 2) pain, 3) activities of daily living, 4) sport and recreational activities and 5) foot and ankle-related quality of life. Zero is the worst, and 100 is the best outcome. The instrument has shown adequate responsiveness and has been translated into several languages [18]. The minimally important change (MIC) for the FAOS in hindfoot surgery has been reported to be 0.3, 9.5, 11.7, 3.5 and 5.0 points for the five dimensions, respectively [19].

The study's secondary objective was to evaluate improvement in health-related quality of life after surgery using the SF-36. This score has eight health domains comprising 36 items concerning 1)

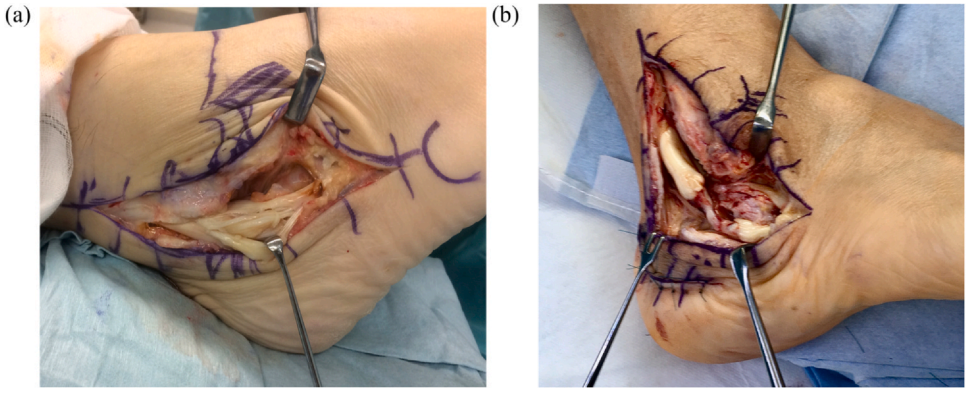

Fig. 1. Severely torn peroneus brevis tendon (a) and severely torn peroneus longus tendon at the peroneal tubercle (b).

physical functioning, 2) role limitations physical, 3) role limitations emotional, 4) vitality, 5) mental health, 6) social functioning, 7) bodily pain and 8) general health. Each of the eight domains is scored from 0 (poor health) to 100 (excellent health). Although not specific to foot and ankle conditions, a change of five points in the scores has been suggested to be clinically relevant [20].

2.2. Statistics

The postoperative results of FAOS and SF-36 were compared with the preoperative results using a paired t-test. P-values for the interaction between FAOS and gender, age, primary or revision surgery and concomitant calcaneal osteotomy were calculated. Multiplicative interactions were considered using product terms and likelihood ratio tests. Spearman's rank correlation coefficient was used to analyse the association between the FAOS and postoperative radiographic varus alignment and BMI. Intraclass correlation coefficient (ICC) was used to compare the surgeon's and radiologist's measurements of radiologic hindfoot valgus alignment measured in millimeters. The measurements had a high concordance, with preoperative ICC= 0.99 (95 % CI 0.94 to 1.00) and postoperative ICC= 0.99 (95 % CI 0.90–1.00). The absolute average difference between the two observers was 0.3 mm for preoperative and 0.2 mm for postoperative measurements, without statistically significant differences (p = 0.36 and p = 0.82). Statistical analyses were conducted in Stata version 15.1 (StataCorp, College Station, TX). The threshold of significance was $p < 0.05$.

3. Results

The cohort comprised 17 men and 15 women. The mean age at surgery was 54 (SD, 10) years. Eleven patients underwent a concomitant calcaneal osteotomy, and one patient underwent a tarsal tunnel release and ankle arthroscopy during the same session. There were no valgus feet on the hindfoot alignment view. (Table 2 and Supplement 2).

3.1. FAOS

The average improvement in overall FAOS at six months was 17.4 points (95 % CI: 9.6–25.1; $p < 0.0001$), and at 12 months, 21.0 points (95 % CI: 12.7–28.0; $p < 0.0001$) (Table 3, Fig. 3). Five patients (16 %) had the same or worse scores at 12-month follow-up than before surgery. In this group, there were four women and one man. The man had a sural nerve injury after a calcaneal osteotomy, with persistent pain. Of the four women, three were reoperations.

Table 2
Baseline characteristics of the 32 patients in the study. Values are numbers (percentages) unless stated otherwise.

Characteristics	Values
Age in years, mean (SD)	54 (10)
Sex, men/women (%)	17/15 (47)
Laterality, left foot/right foot (%)	17/15 (47)
Brevis torn, n (%)	26 (81)
Longus torn, n (%)	6 (19)
Calcaneal osteotomy, n (%)	11 (34)
Previous surgery to the ligaments or tendons, n (%)	8 (25)
Time from debut of symptoms to surgery in months, median (range)	31 (6 –180)
Varus/neutral/valgus hindfoot, on the hindfoot alignment view, n (%)	23/9/0 (72/28/0)
Hindfoot alignment according to Saltzman, mm varus (SD)	5.4 (4.6)
Beighton score, mean (SD)	1.3 (1.6).
BMI, mean (SD)	28.2 (4.0)
Positive drawers test, n (%)	28 (87)

Table 3
Average FAOS values before and after surgery.

	Total score	Other symptoms	Pain	ADL	Sports	QoL
Preoperatively	51.7	56.9	53.7	62	30.5	22
Six months	70.4	65.3	72.7	82.3	53.7	45
12 months	72.7	69.8	76.9	80.7	55.5	54.2
Change preop–12 months	*21*	*12.9*	*23.2*	*18.7*	*25*	*32.2*
MIC (Tapaninaho et al. 2022)		*0.3*	*9.5*	*11.7*	*3.5*	*5.0*

No significant differences in FAOS values were observed between men and women (p-value for interaction 0.18), between patients with or without a calcaneal osteotomy (p-value for interaction 0.72), between those with primary and those with revision surgery (p-value for interaction 0.12) or between patients younger or those older than the median age 55 years (p-value for interaction 0.50). (Fig. 4). There was no correlation between the postoperative FAOS and the postoperative hindfoot alignment on the radiographs (Spearman's coefficient −0.03, p = 0.87), or between the scores and BMI (Spearman's coefficient 0.02, p = 0.92).

3.2. SF-36

SF-36 patient results improved in all eight domains. However, significant improvements were only seen in role limitation physical, physical function and bodily pain (Table 4, Fig. 5). Despite improvement, the mean values at 12 months were still lower than the national mean for this age group [21]. There were no statistical differences between men and women.

3.3. Clinical and radiographic examination

At the 12-month follow-up the anterior drawer test was positive in six patients (19 %), compared with 28 (87 %) preoperatively. According to the Medical Research Council (MRC) scale, the eversion strength was 5/5 in all patients except one, who had 4/5. No infections were reported. Five patients (16 %) developed plantar fasciitis postoperatively. Eight patients (25 %) experienced numbness in the region of the sural nerve; one had disturbing pain. One patient underwent reoperation with a posterior ankle arthroscopy for removal of os trigonum. Change in hindfoot alignment on the radiographs was only observed in patients who had undergone calcaneal osteotomy. Although most patients were observed to have different levels of scarred ligaments during the surgery, in three cases, the lateral ligaments were found to be normal.

4. Discussion

The most important finding of the present study is that, on average, patients with severe peroneus tendon tears experienced significantly improved foot function and physical health-related quality of life after a peroneus longus to brevis tendon transfer and a lateral ankle ligament reconstruction. Although patient-reported outcomes improved, the patients did not experience normal foot function 12 months after surgery. The patients in the present study were older (mean age 54) than those in most earlier studies on peroneal tendon tears, and the "good" results previously reported may have been caused by the selection of younger patients. We conclude that older patients with degenerative tears to the peroneus tendons have less encouraging results after surgery than younger patients. The results align well with the findings from a study by Chinitz et al., which showed a higher mean age in patients with more severe tendon tears [22]. The patients in the present study had supination trauma with a median delay of 31 (range, 6–180) months

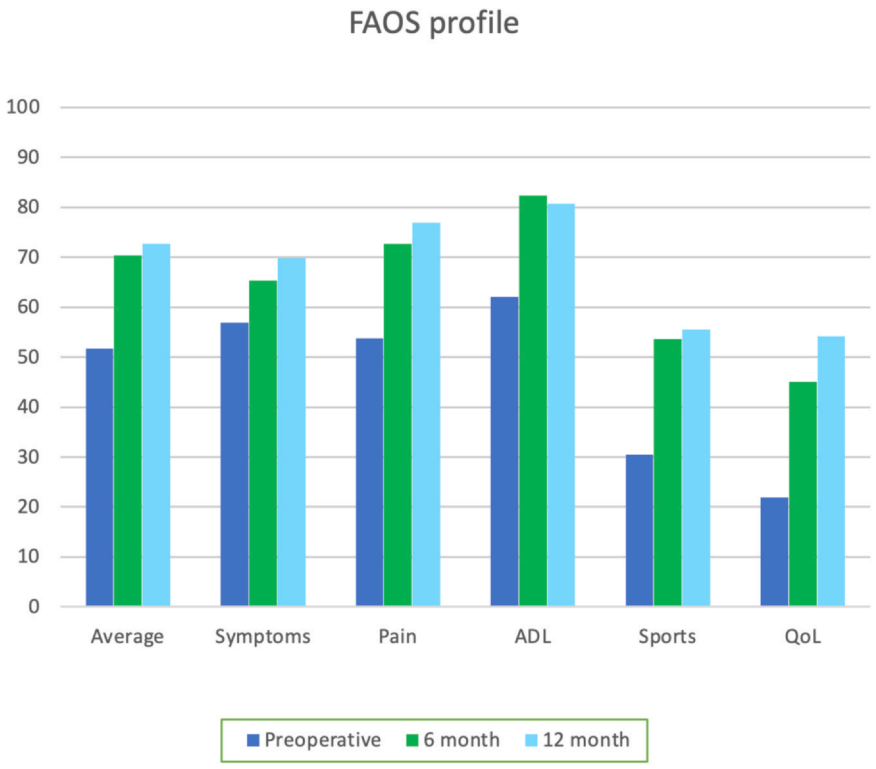

Fig. 3. FAOS profile preoperatively and at six and 12 months after surgery.

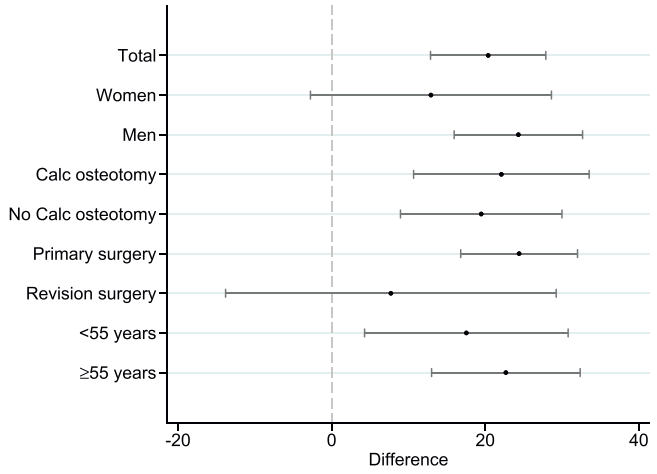

Fig. 4. Forest plot for the overall FAOS result (total) and in subgroups. The solid lines directed from the point estimates represent 95 % confidence intervals.

between the onset of symptoms and surgery. A long delay to surgery is not uncommon in patients with peroneal tendon tears [1,4,6], and it has been reported that patients with symptoms for over a year experience inferior results after surgery, compared with those treated within a year [8].

The SF-36 improved mostly in the physical domains. The instrument has been used in two previous studies on peroneal tendon surgery. In a study on 12 patients with a longus to brevis tenodesis after excision of the os peroneum, the physical component scores changed from 36 points preoperatively to 52 points postoperatively [23]. Higher scores were reported in a study on 14 patients at a two-year follow-up after a peroneus longus to brevis tendon transfer [10].

Few peroneal tendon studies have used validated PROMs. It is still quite common to see the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score being used, which is mainly completed by the clinician [2,4,15,24,27]. A few studies on validated instruments show improved functional outcomes after sutured peroneal tendon tears [6,9]. Validated instruments in the way of the Foot Function Index [24], the Karlsson score [24] and the previously mentioned SF-36, were used in one study on peroneus longus transfer [10]. The results indicate that this procedure delivers promising outcomes.

Table 4
Results from SF-36, mean from 32 patients.

	Physical function	Role: physical	Role: emotional	Vitality	Mental health	Social function	Bodily pain	General health
Swedish mean (Sullivan et al. 2002)	**88.2**	**85.2**	**87.3**	**69.6**	**80.6**	**88.4**	**73.3**	**75.1**
Preoperatively	53.3	26.7	67.8	53.3	75.2	72.2	38.6	66.7
Six months	71.3	61.6	78.5	62.9	83.4	80.1	59	74.2
12 months	74.8	57.3	77.8	58.3	78.3	82.3	60.7	70.6
Mean improvement at 12 months	***20.0***	***28.4***	***10.3***	***2.6***	***2.8***	***7.7***	***19.3***	***3.9***
95%CI improvement	*9.8–30.2*	*8.5–48.4*	*−8.3–28.9*	*4.6–9.8*	*3.0–8.5*	*−0.8–16.1*	*8.3–30.3*	*4.4–8.6*
P-value improvement	*0.0004*	*0.007*	*0.26*	*0.47*	*0.34*	*0.07*	*0.001*	*0.51*

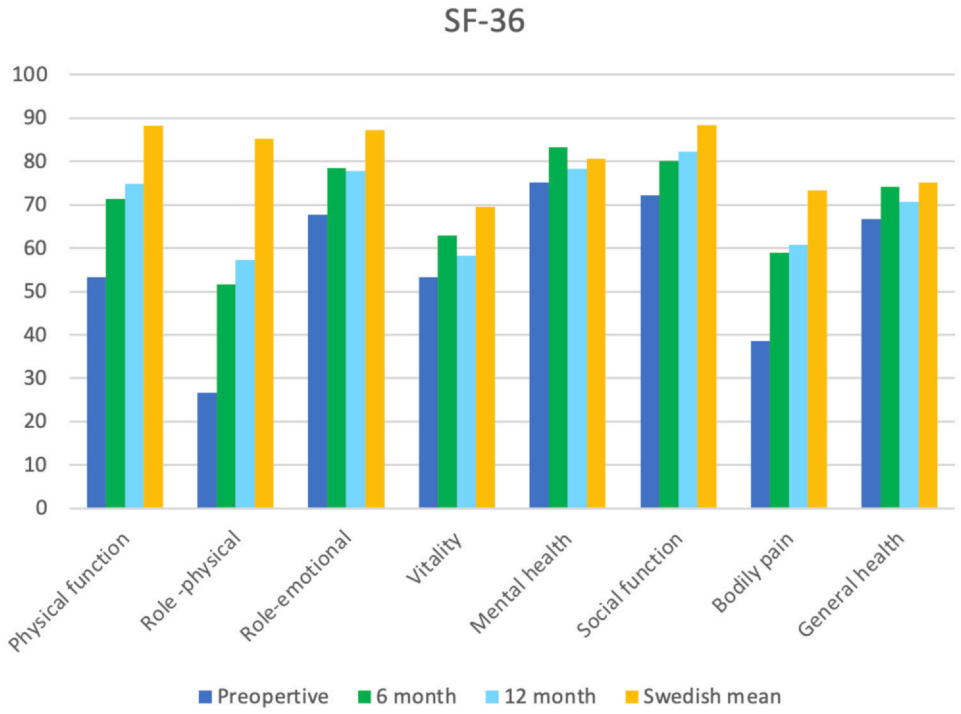

Fig. 5. SF-36 preoperatively and at six and 12 months after surgery, compared with the national mean for this age group.

Previous studies have suggested that if one of the peroneal tendons is severely damaged, it should be sutured to the remaining tendon [2,4]. However, the peroneal tendons have different roles in foot biomechanics, and the peroneus brevis might play a significant role in the stability of hindfoot eversion [22,25,26]. Burkhard et al. tested isokinetic eversion strength in the operated foot after distal peroneus longus to brevis transfer and found it to be similar to that in the contralateral side [10]. This implies that a peroneus longus to brevis tendon transfer does not cause any major motor deficit in foot eversion.

It might not be necessary for all patients with peroneal tendon tears to undergo lateral ankle ligamental reconstruction surgery. In our study, the anterior drawer test preoperatively was negative in 4 patients. However, the surgeon should be aware of the high risk of lateral ligamental injuries in this group of older patients with long-lasting symptoms.

It has previously been claimed that, to avoid recurrent tendon injury, a calcaneal osteotomy should be performed in conjunction with peroneal tendon surgery in cases of hindfoot varus [4,10]. We found no correlation between the postoperative FAOS results and the radiographic level of hindfoot varus. A more precise indication of when to perform a calcaneal osteotomy is currently unavailable in the literature. In the present study, a calcaneal osteotomy was performed if the patient had developed more hindfoot varus than the contralateral side, and we consider this a reasonable algorithm.

4.1. Strength and limitations

The main strength of the present study is the longitudinal follow-up of 32 patients using validated PROMs with a standardized surgical procedure. The main limitation is the short follow-up of 12 months, which was chosen because the patients were part of a more extensive study of post-operative gait analysis that required significant resources. The research question concerning whether patients improve after surgery could nonetheless be answered. However, a longer follow-up might have shown even better results on the FAOS, and we plan a future long-term follow-up. It can also be observed that the clinician's anterior drawer test is subjective; ideally, ankle stress radiography should have been performed. Another limitation is that the lateral ligament reconstruction was used on all patients.

4.2. Conclusion

The present study reports significantly improved patient-reported outcomes after a peroneus longus to brevis tendon transfer in patients with severe peroneal tendon tears in conjunction with lateral ankle ligament reconstruction and an added calcaneus osteotomy in the case of hindfoot varus. Based on our results, the procedure is generally safe.

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Declaration of Competing Interest

None of the authors have any conflicts of interest to declare.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fas.2024.09.008.

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