Modified Zadek osteotomy without excision of the intratendinous calcific deposit is effective for the surgical treatment of calcific insertional Achilles tendinopathy

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ABSTRACT

Introduction: Nonoperative management of calcific insertional Achilles tendinopathy (CIAT) may fail in 10–30% of patients, and various operative procedures have been described to manage those.
Methods: A modified Zadek (dorsal closing wedge) calcaneal osteotomy, without removing the calcific deposits and without detaching the insertion of the Achilles tendon, was performed between November 2016 and December 2017 in 25 consecutive patients (mean age 53.5 years), who were followed for at least 2 years.
Results: The osteotomies had united at an average of 5 weeks. Two superficial wound infections (8%) were documented. Patients had returned to their normal activities at an average time of 23 ± 7.7 weeks. Three out of four patients, who practised recreational sport activity, returned to their pre-injury level. VAS and VISA-A scores had significantly improved at 3 months postoperatively ($p < .001$) and continued to improve for 24 months.
Conclusion: The modified Zadek osteotomy, without excision of the intra-tendinous calcification, was safe, and significantly improved clinical outcome in patients with CIAT at 2 years after surgery.

Level of evidence IV.

Introduction

Insertional Achilles tendinopathy (IAT) involves the enthesis of the distal portion of the Achilles tendon, and is distinct from another condition that affects the distal insertion of AT to the calcaneus, namely calcific insertional Achilles tendinopathy (CIAT).[1–3]

Clain and Baxter[4] originally considered CIAT as a separate entity from other ailmente of the Achilles tendon. CIAT is considered as an overuse enthesopathy of the Achilles tendon, with fibrosis collagen, degeneration and calcific

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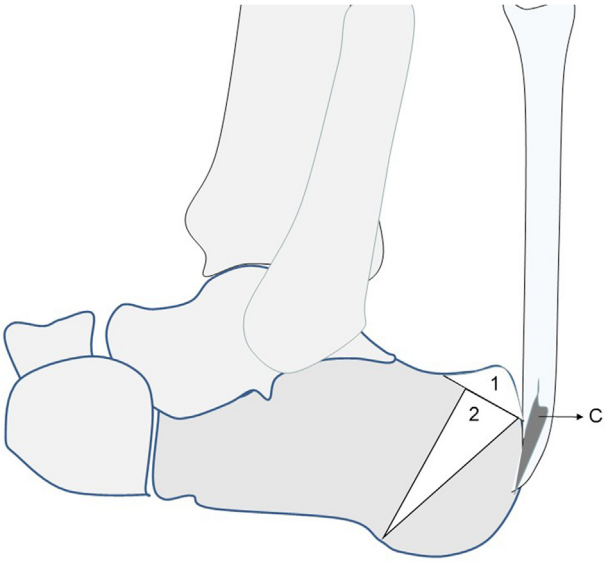

Fig. 1 – Bony cuts illustration. The "Haglund's" bony prominence is removed (1), and then a modified Zadek's osteotomy is performed (2). The intra-tendinous calcification (C), is not removed.

metaplasia of the distal portion of the Achilles tendon at the enthesis.[5,6] The repetitive mechanical load predisposes to microtears inside the tendon, which develop cartilaginous spots with or without atrophic and mucinoid degeneration derived from a change of tensile loads.[7,8] A marked increase in type II and type III collagen accompanying chondroid metaplasia of the resident tenocytes is the most relevant histopathologic alteration during CIAT.[7,9]

CIAT patients may present posterior heel pain l with marked tenderness at the insertion of the Achilles tendon on the calcaneus. Generally, posterior heel pain worsens after exercise or using closed-heel shoes. Plain radiographs usually reveal an evident Haglund's deformity of the posterior calcaneal tuberosity, accompanied by intratendinous calcific deposits at the bone-tendon interface.[4,5]

Several surgical and non-surgical management modalities to manage calcific insertional Achilles tendinopathy have been described.[10–14] Nonoperative management is initially recommended,[15] with success in 70%–90% of patients.[4,5,16]

Rest, ice, careful footwear selection, non-steroidal anti-inflammatory drugs, avoidance of impact and weight bearing activities,[1,4] night splints, small heel lifts, and physiotherapy exercises with stretching of the gastrocnemius–soleus complex may be helpful.[4,5] When compared to midportion Achilles tendinopathy, eccentric exercises for insertional tendinopathy, only have a success rate of around 30%.[10,16,17] Extracorporeal shock wave therapy can be used in chronic cases,[12,13] and surgical management is indicated in patients who did not respond to nonoperative management after at least 6 months.[10] However, there is no consensus about the most appropriate surgical procedure.[18] Traditionally, surgery for IAT involves excision of the retrocalcaneal bursa, resection of the prominent postero-superior corner of the calcaneus (Haglund's) debriding the tendon to bone insertional zone.[1,19]

We understand that use of the term "Haglund's" is controversial. This might be one of the cases in the orthopaedic literature when a term has been used by various authors over the years to describe similar but slightly different conditions.[3] However, this term is widely used to describe the shape of the posterosuperior portion of the calcaneus, and therefore we adopted it in the present article.

Open approaches use medial, lateral or midline longitudinal, or curvilinear incisions.[1] A transverse (Cincinnati) incision can also be used, for tendon insertion debridement and calcaneal Haglund's ostectomy to be performed.[20] Excellent outcomes have been reported.[8,20]

On the other hand, only few investigations specifically focus on surgery in CIAT.[8] Most surgeons recommend to debride the calcific deposits. Debridement can be extensive, and the Achilles tendon may have to be detached and then reattached onto the calcaneus with suture anchors.[1,8] In advanced tendinopathy or during revision surgery, tendon reconstruction may be indicated, including regional tissue advancements, or tendon transfer.[9]

A dorsally based closing wedge osteotomy of the calcaneus was described by Zadek in 1939[21] whilst it was popularised, later, by Keck and Kelly.[22,23] A safe procedure, it offers a high rate of success with few complications (eg. calcaneus shortening, and a beak at the plantar apex of the osteotomy).[22–25] The rationale of calcaneal osteotomy for CIAT, is to alter the mechanics of gastroc-soleus contraction and force transmission through the Achilles tendon, avoiding friction between Achilles tendon and calcaneus.[1,25,26]

The present study reports the technique and outcome of a modified Zadek calcaneal osteotomy, without debriding the calcific deposits and without detaching the Achilles tendon from its calcaneal insertion, in patients with painful CIAT.

Methods

The present study was approved by the Local Ethics Committee of the University of Salerno. It involved prospective enrolment of 25 consecutive patients from November 2016 to December 2017, presenting with posterior heel pain associated with calcific insertional Achilles tendinopathy. All patients had been managed non-operatively for at least six months without resolution of their symptoms, and were tertiary referrals to the senior author (N.M.). They gave written informed consent to participate in the study. We excluded smokers, diabetics, those with metabolic disorders (hypothyroidism, gout), or autoimmune diseases, and those who had previously undergone surgery to the same foot and ankle. All patients were examined by the senior author (N.M.), who confirmed the diagnosis of CIAT by clinical examination and evaluation of relevant imaging (radiograph, MRI). The Royal London Hospital test was used for clinical assessment. It is positive when tenderness and pain at palpation of the AT insertion with the ankle plantar flexed, is relieved when the ankle dorsiflexes.[27] The test was positive in all patients. A weight bearing lateral radiograph of the involved ankle evidenced prominent posterior calcaneal tuberosity and a calcific insertional Achilles tendinopathy. Magnetic resonance

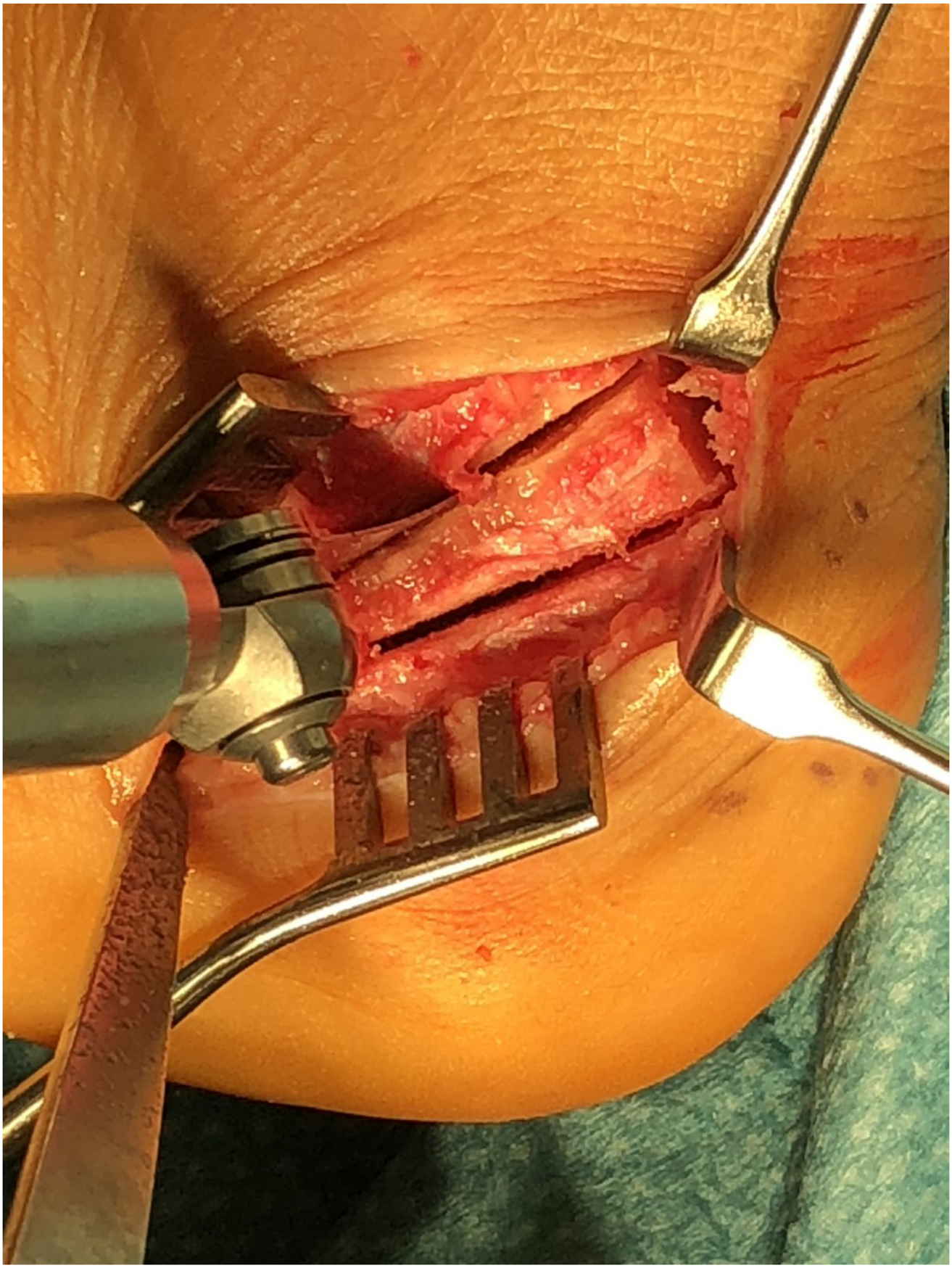

Fig. 2 – Calcaneal osteotomy. Intraoperative view of the dorsal closing wedge osteotomy.

imaging (MRI) scan revealed tendinopathy affecting the insertion of the AT into the calcaneus in all patients.

Surgical technique

Patients were placed in the lateral position, under spinal anesthesia, using calf tourniquet applied three cm distal to the head of the fibula. An intravenous cannula was inserted in a dorsal foot vein on the leg to be operated on for antibiotics (2 g of cefazolin) to be administered, after exsanguination and tourniquet inflation.[14,28–30] The surgical technique has been previously described.[25] We used an oblique lateral heel incision starting just anterior to the Achilles tendon, at a 45° angle to the long axis of the calcaneus well posterior to the course of the sural nerve. A full-thickness soft tissue flap was elevated, to expose the lateral wall of the calcaneus. First, the postero-superior corner of the calcaneus ("Haglund's" bony prominence) was resected using a sagittal saw. A calcaneal osteotomy was then performed, beginning just superior to the calcaneal insertion of the Achilles tendon at approximately a 45-degree angle to the long axis of the tendon. The second cut was performed approx. 1–1.2 cm more anteriorly (Fig. 1). We were careful to preserve a bone hinge at the plantar apex of the wedge. The dorsal base of the wedge measured about 1 cm (Fig. 2).

The bone wedge was removed, and the osteotomy was closed by hand, dorsiflecting the foot to favour closure. A vertical posterior heel incision was made, and two Kirschner wires, were then inserted from the posterior aspect of the calcaneus, over which cannulated screws were used for fixation of the osteotomy (Fig. 3).

The wound was closed using 2-Vicryl (Polyglactin 910 braided absorbable suture; Johnson & Johnson, Brussels, Belgium) continuous suture for the deeper tissues, whilst continuous subcuticular suture using Monocryl 3-0 (Ethicon Ltd, Bridgewater, New Jersey, USA) or metallic staples were used for skin closure. A below-knee cast with the foot plantigrade was applied for four weeks.

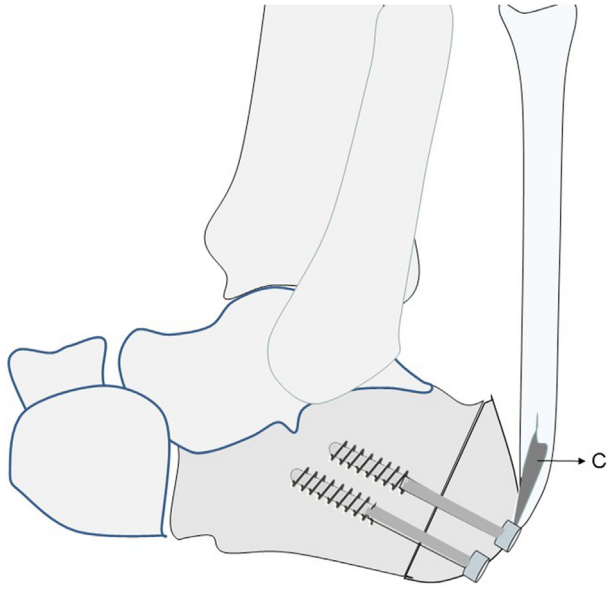

Fig. 3 – Fixation of osteotomy. After the bone wedge has been removed, the opposing osteotomy surfaces are brought together. Two partially threaded cannulated screws are used for fixation. The intra-tendinous calcification (C), has not been removed.

Postoperatively, patients were given 100 mg of Aspirin daily for thromboprophylaxis until they were fully mobile. Patients were advised to regularly mobilise toes, knee and hip at least once an hour during the day. Weight bearing as tolerated in the cast using two crutches was allowed as early as possible. Four weeks after surgery, the cast was removed and an Aircast walker (DJO, Carlsbad, California, USA) was applied, with the foot plantigrade, allowing full weight bearing in the walker. Supervised mobilisation exercises were commenced out of the boot at that stage, with proprioception exercises, isometric contractions of the gastrocnemius–soleus complex, and swimming and stationary cycling were encouraged. After removal of the walker, three months post-operatively, patients were allowed to gradually return to their usual daily life activities.

Patients were assessed at one, three, six, 12 and 24 months after surgery. A visual analogue scale (VAS) pain score (range 0–100) and the Victorian Institute of Sports of Australia-Achilles (VISA-A) score[31] (Table 1), for pre-operative and postoperative evaluation at each patients' follow-up appointment (three, six, 12 and 24 months), were used. The assessment was performed, independently from the treating surgeon, by an orthopaedic fellow (AD), who did not participate in the management of these patients.

Radiographic assessment included lateral hindfoot and axial calcaneal pre- and post-operative radiographs, to assess union of the osteotomy after surgery, and to measure calcaneal length, pre- and post-operatively. The latter was measured on the lateral radiograph, as follows: a line, parallel to the calcaneo-cuboid joint, was drawn, to connect the most superior and inferior points on the anterior calcaneus. From the midpoint of this line, the line to the most posterior aspect of the calcaneus allowed to measure the length of the calcaneus. A researcher who had not been involved in the surgical care of the patients measured each radiograph twice, with a two weeks interval. The average of the two measurements was used for statistical purposes. If there was discrepancy of more than 5% between the two measurements, those were repeated. We assessed this radiographic parameter to record whether our osteotomy exerted any negative effect on the morphology of the calcaneus that could have impacted negatively foot biomechanics.

For statistical analysis the repeated measures one way-ANOVA was used. The Geisser–Greenhouse correction was applied for categorical variables, whilst Student's *t* test for paired data was used to compare VAS and VISA-A pre-operatively and at 24 months follow-up. Data were entered in a Microsoft Excel sheet (Microsoft Corporation, USA), and analysed using GraphPad Prism 8.0 Statistical Software (GraphPad Software, Inc, La Jolla, CA, USA). A p value $< .05$ was considered significant.

Results

Twenty-five patients were enrolled [11 men and 14 women; mean age: 53.5 (range, 32–72) years], and were

followed up for at least 2 years (range, 2–2.4 years). Two patients (8%) developed superficial wound infection and were treated successfully with local wound care and oral antibiotics. One patient (4%) reported initially paraesthesia associated with the sural nerve, but symptoms gradually resolved with no sequelae. There were no major complications (thrombosis, deep infection, osteotomy malunion or nonunion). All patients returned to their pre-surgery level of activities, whilst three of four patients, who used to practise recreational sports prior to developing CIAT, were able to practice those after recovering from surgery. The time to return to previous activities ranged from 4 months to over close to nine months, with an average time of 23 ± 7.7 weeks.

The median VAS score pre-operatively was 58.2 ± 17.7 (range, 25–90), and the median VAS score at 24 months was 22.7 ± 4.44 (range, 18–31) ($p < .0001$) (Fig. 4a).

The median VISA-A score pre-operatively was 35.8 ± 11.46 (range, 19–48), and the median VISA-A score after two-year follow-up was 86.8 ± 9.1 (range, 65–100) ($p < .0001$) (Fig. 4b).

Plain radiographs revealed union of osteotomy at a mean time of 5 weeks (range, 4–10 weeks) (Fig. 5). The calcaneal length had decreased after the osteotomy (*T*-test, $p < .001$). It was on average 84.1 mm (range, 73–99 mm) pre- and 79 mm (range, 72–92 mm) post-operatively, whilst the average decrease was 4.5 mm (range, 3–8 mm).

Discussion

The present study showed that patients' pain and function had significantly improved 3 months after surgery, and that clinical improvement increased progressively over 2 years, without the need to detach the AT and remove the insertional calcification.

These results are in agreement with those of a recent prospective study using the modified Zadek osteotomy in 28 patients with IAT and no intratendinous calcification or spurs. Patients had returned to presurgery level of activities between 4 and 8 months after surgery, whilst their clinical condition

Table 1 – The VISA-A questionnaire: An index of the severity of Achilles tendinopathy.

IN THIS QUESTIONNAIRE, THE TERM PAIN REFERS SPECIFICALLY TO PAIN IN THE ACHILLES TENDON REGION

1. For how many minutes do you have stiffness in the Achilles region on first getting up?

100 mins | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 0 mins | POINTS

2. Once you are warmed up for the day, do you have pain when stretching the Achilles tendon fully over the edge of a step? (keeping knee straight)

Strong severe pain | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | No pain | POINTS

3. After walking on flat ground for 30 minutes, do you have pain within the next 2 hours?
(If unable to walk on flat ground for 30 minutes because of pain, score 0 for this question).

Strong severe pain | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | No pain | POINTS

4. Do you have pain walking downstairs with a normal gait cycle?

Strong severe pain | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | No pain | POINTS

5. Do you have pain during or immediately after doing 10 (single leg) heel raises from a flat surface?

Strong severe pain | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | No pain | POINTS

6. How many single leg hops can you do without pain?

0 ☐☐☐☐☐☐☐☐☐☐☐ 10 POINTS ☐

0 1 2 3 4 5 6 7 8 9 10

7. Are you currently undertaking sport or other physical activity?

POINTS

0	Not at all	
4	Modified training ± modified competition	☐
7	Full training ± competition but not at same level as when symptoms began	
10	Competing at the same or higher level as when symptoms began	

8. Please complete **EITHER A, B or C** in this question.
• If you have **no pain while undertaking Achilles tendon loading sports** please complete **Q8a only**.
• If you have **pain while undertaking Achilles tendon loading sports but it does not stop you from completing the activity**, please complete **Q8b only**.
• If you have **pain that stops you from completing Achilles tendon loading sports**, please complete **Q8c only**.

A. If you have **no pain** while undertaking **Achilles tendon loading sports**, for how long can you train/practise?

Nil	1-10 mins	11-20 mins	21-30mins	>30 mins	POINTS
0	7	14	21	30	☐

OR

B. If you have some pain while undertaking **Achilles tendon loading sport**, but it does not stop you from completing your training/practice for how long can you train/practise?

Nil	1-10 mins	11-20 mins	21-30mins	>30 mins	POINTS
0	4	10	14	20	☐

OR

C. If you have **pain that stops you** from completing your training/practice in **Achilles tendon loading sport**, for how long can you train/practise?

Nil	1-10 mins	11-20 mins	21-30mins	>30 mins	POINTS
0	2	5	7	10	☐

TOTAL SCORE (/100) ……%

(assessed using VISA-A score) had significantly improved at 3 months and continued to improve until 24 months after surgery.[25]

A calcaneal dorsal closing wedge osteotomy reduces friction between bone and tendon, which is considered a potential factor in CIAT pathomechanics. Subsequently, tendon degeneration is triggered, resulting in chondral metaplasia and apposition of calcific deposits within the tendon.[1,3] In the original description, the procedure did not involve the removal of the so called "Haglund's" calcaneal bony prominence. In the present study, we removed the posterosuperior corner of the calcaneus to reduce the above-mentioned friction between tendon and calcaneus. Additionally, by not removing the intra-tendinous calcification, we avoided Achilles tendon detachment from the calcaneus, preserving its integrity.

We acknowledge that we did not undertake pre-operative planning to exactly calculate the size of the wedge to remove. However, to our knowledge there are no indications as to which angle should we aim for. It is possible that small angular changes result in large biological effects. In the present study, the dorsal base of the wedge measures approximately 1 cm. The fact that calcaneal length did not show significant variation post-operatively suggests that the size of the wedge did not differ significantly from patient to patient.

We have also considered the potential regrowth of calcific spurs, which two of us (NM, NG) have observed in the past using different surgical techniques, but has also been reported in the literature.[32] It is also possible that recurrence of the intratendinous calcification may have been underreported in the literature, because it was not one of the outcome measures, follow up may not have been sufficient, but also because it may not be associated with symptoms, as patients could be asymptomatic, despite the relapse of the calcification itself. We did not use advanced imaging (MRI or ultrasound) postoperatively, as patients improved. Since we did not remove the intratendinous calcification, and did not detach or debride the Achilles tendon, a postoperative MRI or

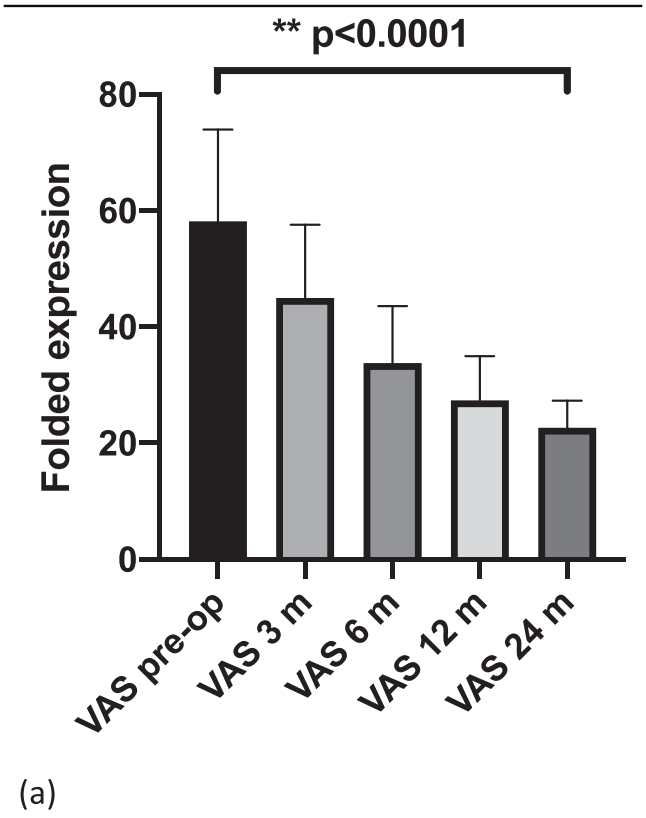

Fig. 4 – Outcome scores. VAS (a) and VISA-A (b) improved significantly ($p < .0001$) after surgery.

ultrasound would not have offered any useful information. In addition, there is little or no association between clinical symptoms and postoperative appearance of the Achilles tendon using those imaging modalities.[33]

Thus, we chose to modify the loading axis, eliminating the "noxa patogena". Finally, considering an economic aspect, there is a saving not using the bone anchors to re-attach Achilles tendon to its distal insertion. One has to also consider the possibility that resection of the "Haglund's" bony prominence alone may have been responsible for symptoms' resolution. Only a randomised comparative study could isolate the effect of each stage of the procedure on CIAT.

Georgiannos et al. reported a case series of 52 young and athletic patients with IAT, but without calcified deposits, outlining good results using the VISA-A score, with a complication rate very similar (10.9%) to that in the present study.[18] They used a different technique, with a more anterior first osteotomy cut of the calcaneus, using one single cannulated screw or staples for stabilisation of the osteotomy. We perform the more posterior cut first, to prevent instability of the fragment. Also, they did not excise the posterosuperior corner of the calcaneus. Patients participating in our study, on the other hand, were generally less active and only a few of them were recreational athletes. It seems, however, that calcaneal dorsal closing wedge osteotomies could be suitable for athletic patients.

Calcifications at the insertion of AT are usually excised surgically. Johnson et al. in a case series of 25 patients treated surgically for recalcitrant CIAT, estimated that they had released approximately 50%–70% of the Achilles insertion. They repaired the AT insertion using two bone-suture anchors, and their patients improved significantly regarding pain and function, evaluated using the AOFAS Ankle-Hindfoot Scale.[6]

Maffulli et al. reported encouraging results of the VISA-A questionnaire in 21 patients treated surgically with detachment and re-insertion of Achilles tendon by using suturing bone anchors. In their case series, only one patient needed a further surgical operation.[8]

Watson et al. reported that 11 feet (58%) in a series of IAT with calcified spurs developed postoperative insertional calcification formation, detected on at the final follow-up radiographs. Of those, eight (73%) were "satisfied", and three (27%) were "satisfied with reservation".[32]

Gillis and Lin reported satisfactory outcomes between 75 and 100% in 14 patients treated for CIAT with AT detachment repaired using two bone anchors.[34]

Howell et al., in a retrospective case series of 48 feet in 45 patients treated surgically for CIAT with calcification excision and tendon detachment, transferred the tendon of flexor hallucis longus (FHL). At final follow-up, 30 of 35 patients (86%) who completed a patient satisfaction questionnaire were very satisfied with the outcome and would have the operation done again.[9]

Johansson et al. operated on 36 feet in 34 patients, removing the calcific spurs, and resecting a concomitant Haglund's deformity of the calcaneus in 29 feet (81%). Although 69% of patients reported satisfactory outcomes, two patients with poor outcome required revision surgery because of re-growth of the calcifications.[5]

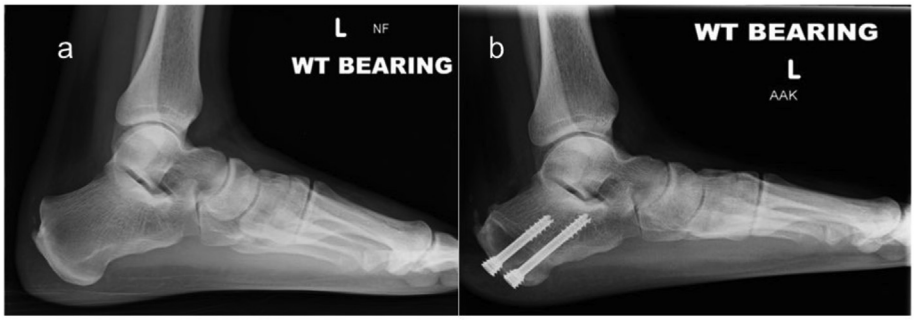

Fig. 5 – Radiographic appearance. Pre- (a) and postoperative (b) lateral radiographs.

Of 34 patients treated surgically for painful CIAT, six (17.7%) had full-thickness calcification of the Achilles tendon insertion on the calcaneus. The calcified tissue within the insertional portion of the Achilles tendon was excised, and a V-Y advancement was used to reconstruct the Achilles tendon insertion.[15]

Given the weak evidence in the literature, it is controversial whether intra-tendinous calcification excision and tendon detachment and re-attachment are necessary for the surgical management of CIAT. The same applies to resection of Haglund's bony prominence. Earlier, we explained our rationale for not removing the calcified tissue. Removal of Haglund's (modifying the original Zadek osteotomy), on the other hand, was performed to eliminate bone-tendon friction that is considered part of CIAT's pathomechanics. It was easily performed through the surgical approach that was used, and was unlikely to add morbidity or prolong recovery.

The need for AT debridement, in addition to the osteotomy that changes mechanics, off-loading the AT insertion, is debatable. Only larger scale randomised studies may shed some light into what type of procedure (e.g. type of osteotomy, debridement of Achilles tendon insertion, detachment and re-insertion of AT) yields better outcomes.

We would also like to point out that one common reason for failure of surgery seems to be attempts at too early return to sport. Because CIAT seems to be associated with unphysiological stress-shielding rather than overuse, it is logical to follow a relatively conservative post-operative protocol, allowing the tendon to adapt to the altered mechanical environment.

Limitations of the present study include the relatively small sample size and the lack of control group. As mentioned earlier, a randomised controlled trial comparing two or more techniques could demonstrate which type of procedure offers superior outcomes. We also acknowledge that functional outcome could have been assessed (e.g. recording force produced by the gastrocnemius–soleus complex).

On the other hand, the surgeries were performed in a homogenous cohort of patients with calcific insertional tendinopathy of the Achilles tendon by an experienced fellowship trained orthopaedic surgeon, who had been using this surgical technique for more than 10 years prior to starting the present study.

Conclusion

The modified Zadek calcaneal dorsal closing wedge osteotomy is a safe and effective surgical technique for the management of CIAT, not requiring calcification excision and consequent tendon detachment. Pain and function improved at a minimum of two-year follow-up.

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