Achilles tendinopathy: new insights in cause of pain, diagnosis and management

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Chapter 11

Optimization of portal placement for endoscopic calcaneoplasty

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ABSTRACT

Purpose

The purpose of our study was to determine an anatomical landmark to help locate portals in endoscopic calcaneoplasty (EC).

Methods

The DOPP (Device for Optimal Portal Placement) was developed to measure the distance from the distal fibula tip to the calcaneus (DFC) in 28 volunteers to determine the location of the posterosuperior calcaneal border in relation to this line.

Results

The DOPP demonstrated an inter-observer reliability of 0.99 (95%CI 0.97-0.99). We found that in patients with flat feet, portals should be placed at a mean of 15 mm (SD 4.5) distal to the tip of the fibula, in normal feet at 20 mm (SD 4.8) and in cavus feet at a mean of 22 mm (SD 5.4). The difference of the DFC within the 3 different foot type groups was significant ($p<0.05$).

Conclusions

The DOPP demonstrated to be highly reliable in measuring the DFC (ICC= 0.99). A numeric distance scale for use in all different foot morphologies could not be constructed. There is a direct relation between portal location and foot morphology ($p<0.05$), as in flat feet portal location is significantly more proximal (15 mm) to the tip of the fibula when compared to cavus feet (22 mm).

Clinical relevance

These results may help with portal placement in endoscopic calcaneoplasty for all different foot morphologies.

INTRODUCTION

Endoscopic calcaneoplasty (EC) has demonstrated to be an effective surgical procedure for treatment of patients with complaints of a retrocalcaneal bursitis not responding to conservative treatment[5,6,14,19]. Two portals are used, just lateral and medial to the Achilles tendon, at the level of the posterosuperior tuberosity of the calcaneus (Figure 1). During the procedure, the inflamed retrocalcaneal bursal tissue and posterosuperior tuberosity of the calcaneus are resected. However, due to the local anatomy, bulky subcutaneous tissue and swelling of the retrocalcaneal bursal tissue, palpation of the posterosuperior calcaneal rim is difficult and portals can easily be placed too far proximal. This will result in a suboptimal procedure. Fluoroscopy is sometimes used to make portals, but can be time-consuming and the surgeon has to depend on availability and personnel. Additionally, retrocalcaneal bursitis often occurs in young patients in whom especially radiation has to be limited to a minimum. For this reason there is need for standardization of these portals. Portals in the area that have been standardised are those for hindfoot endoscopy[18].

In the standard 2-portal hindfoot technique, the distal tip of the fibula is used as an anatomical landmark for placement of the posteromedial and -lateral portal[16-18]. A probe is hooked under the tip and is held parallel to the foot sole which in turn is placed in a 90 degree position with the lower leg. A (imaginary) line is drawn from the tip to the Achilles tendon and the portals are made just above this line (Figure 2). The aim of this study was to determine the optimal location for the portals in EC in relation to this line and to determine if this distance is reproducible in all individuals.

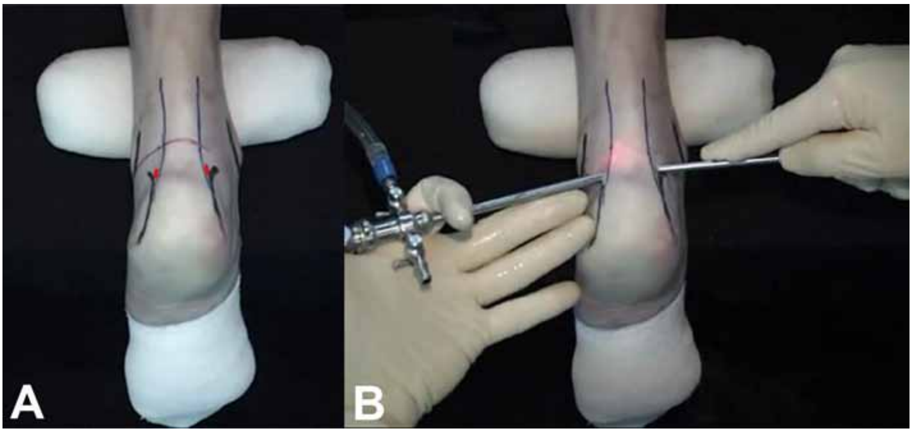

Figure 1. (A) Medial and lateral portal for endoscopic calcaneoplasty (red marks). Portals are placed at the posterosuperior calcaneal tuberosity. **(B)** Arthroscope is placed in the lateral- and a bonecutter shaver in the medial portal

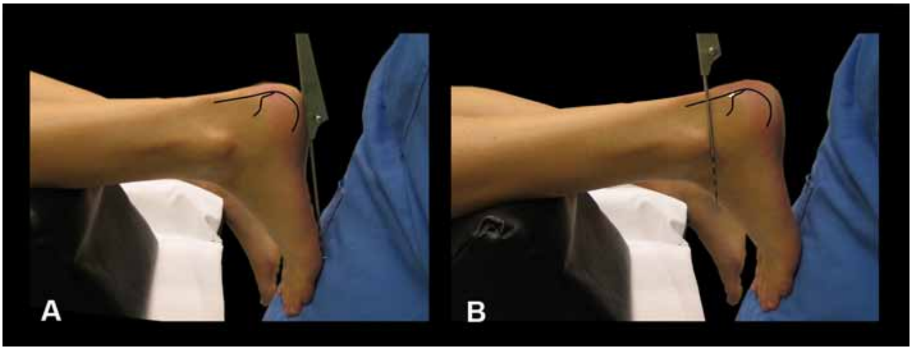

Figure 2. (A) The tip of the fibula, used as a landmark in the standard 2-portal hindfoot procedure. The lateral incision in standard posterior arthroscopy is made just lateral to the Achilles tendon. The portal for endoscopic calcaneoplasty is located at the level of the posterosuperior calcaneal tuberosity (white mark in **B**)

The hypotheses were that the DOPP is a valid tool for standardizing portal placement, and that using the *distance* from the distal tip of the fibula to the posterosuperior calcaneus (DFC) on a radiograph would help us determine the ultimate position of portals, and provide us with a numeric distance- scale to be used in all different foot morphologies.

METHODS

Population

This study was approved by our local Medical Ethical Committee.
It was decided to use healthy volunteers, as the goal of the procedure is to correct the posterosuperior calcaneus to a normal situation with some overcorrection. Portals should not be placed above a possible posterosuperior calcaneal prominence, as the shaver may consequently not be able to reach the level of insertion.

28 volunteers with a mean age of 25 (SD 3.7) without a history of foot surgery or trauma were recruited. Informed consent was signed, patient history was taken and physical examination was performed to assess foot morphology. Of each volunteer one foot was used for measurements and analysis[2]. Age, weight, length and Body Mass Index (BMI) were recorded. Of all volunteers 3 lateral radiographs were made.

Foot morphology

We considered foot morphology important since as the calcaneus tilts the DFC probably increases with cavus- and decreases with flat feet (Figure 3). It was decided to group morphology into three generally used types: cavus, normal, and flat feet.

Figure 3. The DFC is larger in cavus feet **(A)** as compared to flat feet **(B)**

Figure 4. (A) The TMT1- angle measures the alignment of the forefoot with respect to the hindfoot, which is useful for interpretation of cavus and planus deformities. The intersection of the talar and the first metatarsal longitudinal axes creates this angle. Normal is 0°, whereas angles are increasingly negative for cavus deformities (forefoot plantar flexion on the hindfoot) and increasingly positive for flat foot malformations (forefoot dorsiflexion on the hindfoot)[1,3,7,9,10,15,20]. The TMT1-angle is the intersection of the talar and the first metatarsal longitudinal axes. **(B)** The CI-angle is measured by a line passing parallel to the floor and a second line passing along the inferior border of the calcaneus (Figure 4B). A normal angle is 30°, in cavus feet it is more than 30°, and in flatfeet it is decreased [1,9,13,15]

Physical examination as well as radiography was used to determine foot morphology. A foot was defined as ‘flat’ when there was flattening of the medial longitudinal arch in weight-bearing and apparent bowing of the Achilles tendon to medial (Helbing sign) as viewed from posterior. A foot was defined as cavus when there was hindfoot varus and an increase in height of the medial longitudinal arch of the foot that did not flatten on weight-bearing.

Talo 1st metatarsal (TMT1) - and calcaneal inclination (CI) angles[11,12] as measured on a standard lateral weight-bearing radiograph of the foot were used (Figure 4).

The DOPP, ‘Device for Optimal Portal Placement’

It was aimed to measure the DFC on a lateral radiograph. This appeared impracticable since overlying structures make the tip of the fibula difficult to identify. Also, when measuring the DFC per-operatively on a patients foot, there is soft tissue interposition between probe and fibula. Therefore we constructed a device prior to study initiation with which a metal probe can be hooked underneath the tip of the fibula, hereby mimicking the setting in standard 2-portal hindfoot endoscopy (Figure 5A).

Radiographs with the DOPP were made in a sitting position with the ankle in 90° (Figure 5B). We chose this position to reproduce the conditions of the surgical procedure as accurate as possible. The surgeon positions the ankle in 90° when creating the portals in standard 2-portal hindfoot endoscopy. We consider the force used by the surgeon best comparable to the axial force sitting-down. The device was handled by 1 observer throughout the study and repositioned with each radiograph.

Radiographs

All radiographs were made by a radiology technician. Per volunteer 1 standard lateral weight-bearing radiograph with the foot in 20 degrees endorotation and 2 radiographs with the DOPP (alternative radiographs) were made. Radiographs with the DOPP were made in a neutral position to mimic the surgical setting. Next to measuring the DFC, the 2 radiographs with the DOPP were also used to assess intra-observer reliability of placement of the DOPP. All measurements were performed digitally using PACS (Picture Archiving and Communication System) Viewer by Agfa Health Care, Mortsel, Belgium.

Measurement of the DFC on radiographs was performed according to the methods explained in figure 6. The acceptable variation of the DFC between two measurements per volunteer was set to a maximum of 5 mm. This is the diameter of the bonecutter shaver used, chosen as the radius in which the shaver can be moved without having to lengthen or change portal location. We use this shaver to reduce the tuberosity in EC. If variation remained within a limit of 5 mm, the retrocalcaneal space would still be accessible for the surgeon.

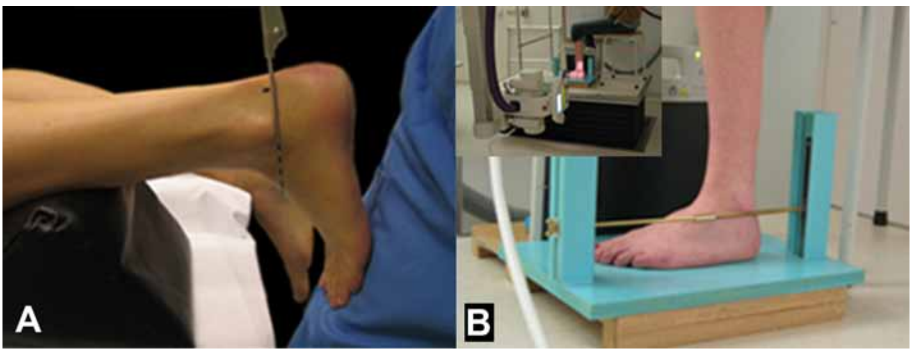

Figure 5. (A) Portal placement in standard posterior arthroscopy, using the distal tip of the fibula as a landmark. **(B)** Mimicking this surgical setting with the DOPP

For all measurements intra- and interobserver reliability were calculated.

Statistics

Results were analyzed with SPSS (Statistical Package for the Social Sciences) 15.0 for Windows. Volunteer characteristics are described as means and standard deviations or proportions.

For intra- and interobserver reliability for the measurements of the CI- and TMT1- angles, Intra Class Coefficients (ICC) with 95% confidence intervals (CI) were calculated; an ICC of 0 - 0.2 indicates a poor reliability, 0.21 - 0.4 is fair, 0.41 – 0.6 is moderate, 0.61 – 0.8 is substantial, and values between 0.81- 1.0 indicate high reliability[8].

Intra-observer reliability for handling the DOPP was tested by calculating ICCs with a 95% CI. To illustrate the variation for repeated measurements, we presented a Bland and Altmann plot. This shows the limits of agreement and the 95% confidence interval with an acceptable variation of 0 ± 5 mm.

Figure 6. Digitally measured distance between the posterosuperior part of the calcaneus and the distal tip of the fibula (DFC, red arrow). **Line A**: foot sole; **Line B**: probe of the DOPP hooked under the tip of the fibula (which seems separate from the bone due to soft tissue interposition); **Line C**: continuation of a line through the vertical aspect of the posterior calcaneal tuberosity; **Line D**: prolongation of a horizontal line from the anterior to the posterior aspect of the calcaneal tuberosity; **Line E**: helpline parallel to line B (and A) through the junction of lines C and D

The clinical validity of the DOPP was assessed through determination of the differences in distance measured on radiographs between the three foot types by means of an ANOVA-test, and if necessary, an additional post hoc Bonferroni multiple comparisons test was applied. Pearson correlation coefficients were calculated to assess association between DFC and TMT1- and CI- angles, length and shoe size.

Spearman *r* correlation coefficients were calculated between the DFC and the categorized variable (foot type according to physical examination).

Pearson- and Spearman correlation coefficients were interpreted as 0.0-0.2 being no; 0.2-0.4 low; 0.4-0.7 moderate; 0.7-0.9 high; and above 0.9 very high[4]. A p-value < 0.05 was considered statistically significant.

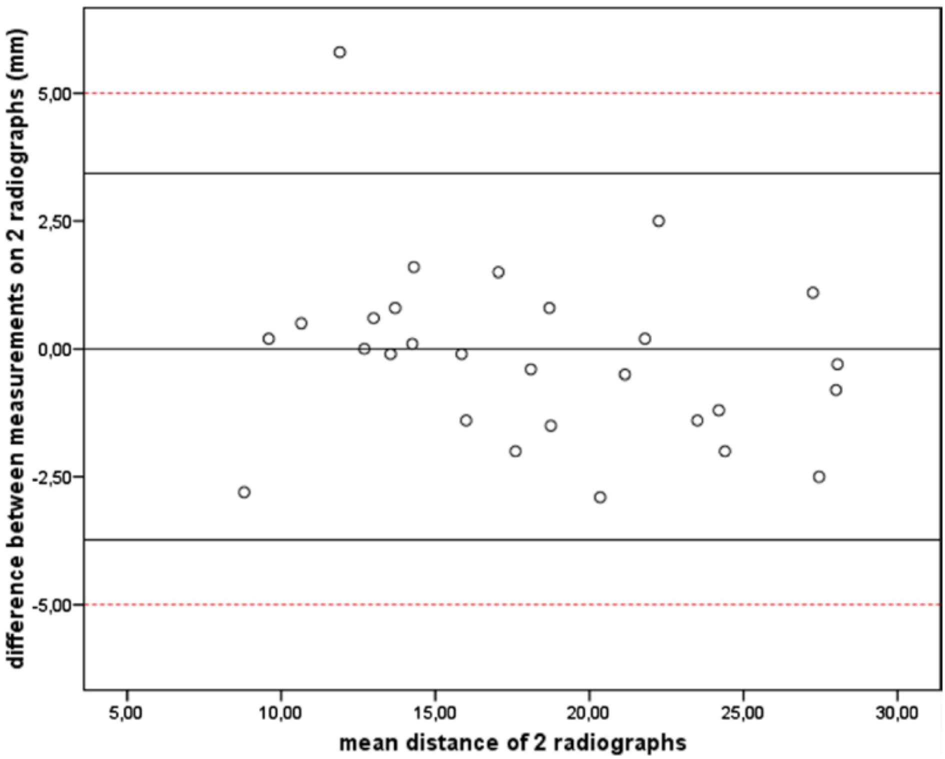

Figure 7. Bland and Altmann plot

RESULTS

Demographic Statistics

Demographics of the volunteers are shown in Table 1. Twenty-four (85.7%) participants actively participated in different sports. A 'too many toes-sign' was observed in 7 volunteers (25%).

According to physical examination, we included 10 volunteers with normal feet (a normal arch), 11 with flat feet (flat arch) and 7 volunteers with cavus feet (high arch).

Table 1. Demographics of the subjects, in means and standard deviations (in brackets)

	Volunteers (n=28)
Age (years)	24.5 (±3.7)
Male/Female	8/20
Weight (kg)	69.3 (±13.3)
Length (m)	1.75 (±0.1)
BMI (in kg/m²)	22.5 (±3.5)
Left/right foot	15/13

Talo 1st metatarsal (TMT1) and calcaneal inclination (CI) angle

The forefoot of the first five consecutive volunteers was not properly visible on radiographs because of technical difficulties, making it impossible to measure the TMT1-angle. We did not make an additional radiograph to prevent them from exposition to more radiation than agreed upon with the Medical Ethical Committee. The mean TMT1- angle was 0.1° (SD 9.8). According to the classification described earlier, 9 had a flat arch, 6 had a normal arch and 8 volunteers had a high arch. Intra-observer reliability for the TMT1-angle showed ICC values of 0.98 for both observers. Inter-observer reliability for the TMT1-angle was high with an ICC of 0.91 (Figure 7).

The mean CI- angle was 21° (SD 6.1). According to the classification, 13 volunteers had a flat arch, 12 a normal arch, and 3 a high arch. Intra-observer reliability for the CI-angle was 0.99 for both observers. The inter-observer reliability showed an ICC-value of 0.98.
No significant correlation was found between BMI, and TMT1- and CI- angle ($p>0.1$).

The DOPP

The intra-observer reliability for handling the DOPP, demonstrated an ICC of 0.96. The inter-observer reliability for radiographic measurements of the DFC showed an ICC of 0.99 (95% CI 0.97-0.99). Figure 7 shows the variation for repeated measurements. The red dotted lines indicate the acceptable variation of 0 ±5 mm. 95% of our measurements lie within 3.4 and -3.7 mm. This is within limits. In one volunteer the difference in DFC between two measurements was more than 5 mm due to an error positioning the DOPP for the first radiograph.

Table 2. Descriptive and reliability numbers for the footprint measurements and radiographic angles (for all correlations p< 0.05)

	TMT-angle (n=23)	CI-angle (n=28)
Mean (SD)	0.1 (±9.8)	21 (±6.1)
Min	-17	12
Max	20	33
Classification	9 flat arch 6 normal arch 8 high arch	13 flat arch 12 normal arch 3 high arch
Intra-observer reliability observer 1	0.98 (95%CI: 9.94-0.99)	0.99 (95%CI: 0.97-0.99)
Intra-observer reliability observer 2	0.98 (95%CI: 0.96-0.99)	0.99 (95%CI: 0.98-1)
Inter-observer reliability	0.91 (95%CI: 0.74-0.97)	0.98 (95%CI: 0.96-0.99)
Correlation with physical examination	0.77	0.72

Table 3. Pearson's correlations between DFC and different variables. (*statistically significant with p <0.05)

Correlations (n=28)	DFC (Distance Fibula-Calcaneus)
Physical examination	0.54*
TMT-angle	0.60*
CI-angle	0.59*
Shoe size of volunteers	0.39*
Length of volunteers	0.09

Correlation between the radiological measurements and physical examination showed that the TMT1-angle had the best correlation (Table 2).

DFC in different foot morphologies

Correlation between the DFC and different variables are shown in Table 3.

The Spearman r correlation analysis revealed moderate correlations (r = 0.54 and 0.60, $p < 0.05$) between foot morphology on physical examination and DFC and TMT1- angle and DFC respectively.

The mean DFC for all feet was 18 mm (SD±5.6), with a range of 7.4 - 28 mm. Classifying the various foot types according to physical examination, mean DFC for the group with flatfeet was 15 mm (SD 4.5). The mean DFC for the group with normal feet was 20 mm (SD 4.8) and for the group with cavus feet the mean DFC was 22 mm (SD 5.4) (Figure 8).

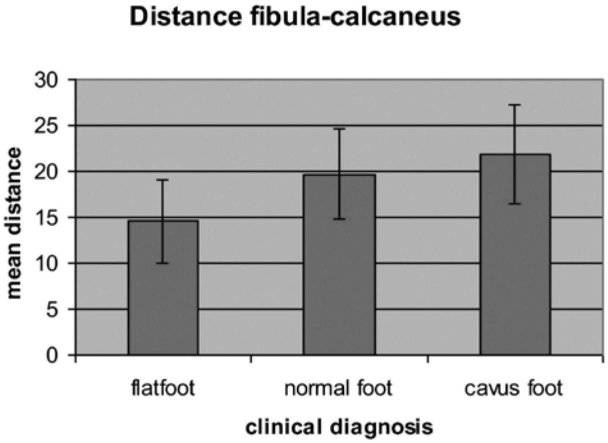

Figure 8. Mean distance for foot type according to physical examination. The distance shows marked overlap all three foot morphologies; there was no significant difference between the distance in flat- and normal or normal- and cavus feet. The Bonferroni multiple comparisons test did reveal a significant difference for the DFC between the group with flat feet and the group with cavus feet (p=0.01)

The ANOVA-test showed a significant difference of the DFC within the three different foot type groups ($p<0.05$). Additionally, the Bonferroni multiple comparisons test revealed a significant difference for the DFC between the group with flat feet and the group with cavus feet (p=0.01). However, the same test did not reveal a significant difference for the DFC between the group with flat feet and normal feet (p=0.07). Also, no significant difference for the DFC was found between the group with normal feet and the group with cavus feet (p=1.0).

DISCUSSION

The DOPP demonstrated to be a reliable instrument and radiological measurements for DFC were highly reliable. The most important findings were that portal location in patients with a flat foot should be placed at a mean of 15 mm from the tip of the fibula, in normal feet at 20 mm, and in cavus feet at a mean of 22 mm distal to the tip of the fibula.

Because ultimately most orthopaedists will determine foot type through physical examination, the most important correlation of the DFC is with foot morphology according to the physical examination and not the TMT-1 angle. The loss of 5 patients for measuring the TMT angle is a limitation of our study.

Our presumption that as the calcaneus inclines, the DFC gets larger seems evident. However, correlation between the DFC and the CI-angle was moderate. Furthermore, not all volunteers with cavus feet showed a high CI- angle. This may be due to the fact that cavus is not always associated with a large CI-angle[13]. As a result of that, the distance of the posterosuperior calcaneus to the tip of the fibula is smaller than we expected in several cases. Also reported is that some volunteers with a normal foot shape showed a rather high CI-angle. Due to hyperpronation, some feet appeared to be flat feet, where hyperpronation and flat feet are two different morphologies that *can* co-exist. In these cases, on physical examination foot shape was normal with a radiographic high CI-angle, rendering a larger than expected DFC. This could explain why there is marked overlap of DFCs between the group with normal feet and the group with cavus feet.

Correlation between physical examination and DFC was also moderate so that a numeric scale for portal placement based on foot morphology (angles) could not be constructed from our study. Apparently, the various foot types show a marked overlap between the distances from calcaneus to fibula. We can conclude however that in flat feet portal location is significantly more proximal to the tip of the fibula, when compared to cavus feet. We realize that we included a limited amount of volunteers; with a larger population we might also find a significant difference between the DFC in flat and normal- and normal- and cavus feet.

The DOPP demonstrated to be highly reliable; with the limitation that only one observer handled the DOPP throughout the whole study. Future research is still needed to determine the inter-observer reliability for using the DOPP, and thereby its validity. The next step could be testing the correlation of the DFC as measured pre-operatively with measurements of the distance of the fibula tip to the incision as placed by an experienced orthopaedist. When correlation is high, the DOPP might eventually be implemented in the daily clinic on individual patients with a retrocalcaneal bursitis scheduled for EC. Until then, when uncertain about portal placement, using fluoroscopy can be considered.

CONCLUSION

The DOPP demonstrated to be highly reliable in measuring the DFC (ICC= 0.99). A numeric distance scale for use in all different foot morphologies could not be constructed. There is a direct relation between portal location and foot morphology ($p<0.05$), as in flat feet portal location is significantly more proximal (15 mm) to the tip of the fibula when compared to cavus feet (22 mm).

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