Performing arts medicine with a focus on Relevé in Dancers

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Chapter 8

Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in dancers: results of open surgery

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Abstract

Posterior ankle impingement syndrome (PAIS), the result of posterolateral soft tissue and/or bony impingement of the ankle, and tendinopathy of the flexor hallucis longus (FHL tendinopathy) in the ankle, are common in dancers. If conservative treatment of these conditions fails to produce adequate results, surgical intervention might be necessary. However, outcomes of treatment by open surgery for these diagnoses have been described only in small series of dancers. For this study data were extracted from clinical files and operative reports of an orthopaedic surgery clinic specialized in dance medicine. Prior to October 2016, 148 patients (82.1% female, median age 19 years) underwent 190 open procedures, 57 (30%) for FHL, 83 (43.7%) for PAIS, and 50 (26.3%) for a combination thereof. In 90.8% of cases patients reported a "better" or "much better" post-operative outcome. There were only minor, transient complications that neither required re-intervention nor influenced outcome. Patients were followed-up for a median of 157 days (interquartile range 91-245). Those operated on by a lateral approach were discharged from follow-up earlier (lateral 113 days vs 190 for medial approach, $p = 0.005$), but there was no difference of outcome at discharge. It is concluded that the open surgical treatment of PAIS and FHL tendinopathy in dancers has a high success rate, and can be considered a successful standard operative procedure. More detailed information is needed about dance-specific outcomes and the early post-operative course of rehabilitation.

Figure 1: On pointe

Figure 2: Tendu

Figure 3: Relevé or demi-pointe

Introduction

Dancers are athletes who put a unique strain on their musculoskeletal system. One of the special requirements is the extreme range of motion demanded of the foot and ankle complex. Dancing on pointe ("full-pointe" or "sur-les-pointes," Figure 1), tendu (Figure 2), and relevé (or "demi-pointe," Figure 3) are ankle positions that are dance-specific and require maximal plantar flexion of the talo-crural joint. The forceful plantar flexion of the foot-ankle-complex that these positions have in common produces compression between the calcaneus and the posterior aspect of the tibia, and in these positions the flexor hallucis longus (FHL) is an important stabilizer of the foot.

Both demi-plié (Figure 4) and grand-plié (Figure 5) are also very common in dance and require weight-bearing maximal dorsiflexion of the talo-crural joint, stretching especially the posteriorly located FHL tendon, and causing "wringing out" of its blood supply, which is already at risk due to an avascular zone posteriorly of the talus.[1] Furthermore, in grand-plié a distally inserting FHL muscle belly is pulled down into the FHL tunnel ("cork in bottle phenomenon"[2,3]) causing entrapment, especially if there is limited space due to a bony impediment.[4,5]

Posterior ankle impingement syndrome (PAIS), or "dancer's heel," and tendinopathy of the flexor hallucis longus (FHL tendinopathy), or "dancer's tendinitis," are common in dancers. PAIS is an acquired problem related to relevé and especially found in dancers who do pointe work. Both relevé and the en pointe position require stretching and training over many years to enable

Figure 4: Demi-plié

Figure 5: Grand plié

a dancer to achieve this maximum ankle excursion and to allow the talus to glide under the dome of the tibia in close proximity of the calcaneus. Symptoms of bony impingement in PAIS are a painful relevé and pain postero-laterally as an os trigonum (Figures 6-7) or hypertrophic posterior process of the talus gets impinged between the tibia and the calcaneus.

Figure 6: Radiograph on relevé: os trigonum (Shepherd's fracture) behind the talus gets impinged between the tibia and the calcaneus

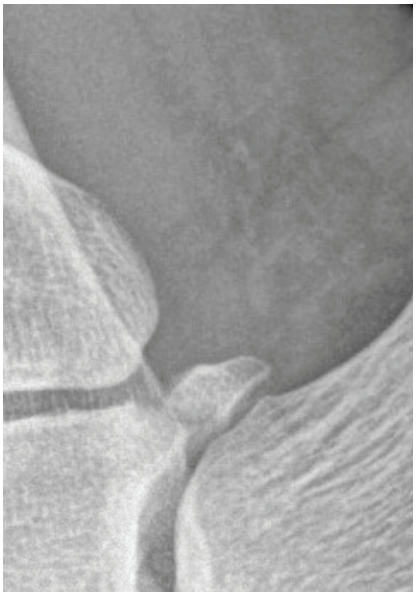

Figure 7: Same as Figure 6; close-up of os trigonum (Shepherd's fracture) in the center of the picture

Diagnostic tests that are commonly used for PAIS are the "plantar flexion test," in which repetitive, quick passive hyper-plantar flexion movements are performed by the examiner,[2,6] or the "ankle McMurray test," in which passive plantar flexion is performed slowly by the examiner, making a rotating movement with the foot from eversion to inversion (and vice versa) while at the same time giving upward compression on the calcaneus. These tests are generally accepted, but not yet validated.[7]

For reasons not fully understood, PAIS often coincides with FHL tendinopathy. Tendinopathy of the FHL is characterized by pain posteriorly and plantarly of the medial malleolus with plié, as the tendon makes an acute angle posteriorly of the talus and slides in an often narrowed and irritated sheath toward the sustentaculum tali. Diagnosis is made when the typical pain is elicited by pressure on the entrance of the FHL tunnel posteriorly and distally from the medial malleolus. In case of a "functional hallux rigidus" the typical pain will be elicited by compressing the FHL tunnel and at the same time forcing the hallux and the ankle into maximum dorsiflexion; this pulls a distally inserting FHL muscle belly down into the FHL tendon tunnel ("like a cork in a bottle").[2,8] The FHL tendon itself may demonstrate fusiform thickening or central necrosis, and in more severe instances calcific nodules or partial degenerative tears in the tendon may lead to triggering of the hallux.[2,9-11] X-ray examination of the foot and ankle complex can be obtained to study whether a bony impediment is present. MRI is only indicated when no conclusive diagnosis can be reached based on history and physical examination.

Although evidence is lacking, it is assumed that in most cases, especially in soft tissue impingement, the symptoms of PAIS and FHL resolve with conservative treatment such as corrected technique, physiotherapy, home exercises, NSAIDs, and corticosteroid injections.[12] However, in some cases there is an etiology that limits the dancer's range of motion and fails to improve. These refractory cases may be due to FHL tendinopathy, bony impingement, or a combination thereof. The types of bony impingement are an os trigonum, Stieda's process (Christian Hermann Ludwig Stieda, German anatomist, 1837-1918), or Shepherd's fracture (Francis J. Shepherd, Canadian surgeon, 1851-1929: Figures 6-7).[13-15] When conservative care fails, surgery is necessary. The surgical approach differs based on the pathology that is causing the impingement.

Open surgical treatment of PAIS in dancers was described for the first time in 1972,[16] of FHL tendinopathy in 1976,[17,18] and of trigger toe in 1979.[11] Isolated PAIS due to an os trigonum or hypertrophic posterior process of the talus in dancers is surgically approached laterally. An incision is made posteriorly of the lateral malleolus, and after identification and protection of

the sural nerve capsulotomy is performed to find the os trigonum or hypertrophic posterior process, which is subsequently removed.

FHL tendinopathy in dancers is surgically approached medially. The incision is made posterior to the medial malleolus, after which the neurovascular bundle is freed and retracted posteriorly to identify the tunnel of the FHL, which is subsequently released. Also in cases of FHL tendinopathy combined with PAIS a medial approach is used, the bony impediment is found deep of the FHL tendon, and subsequently removed (see Figures 8-13). Post-operatively the dancer-patient is usually supervised by a specialized physiotherapist.

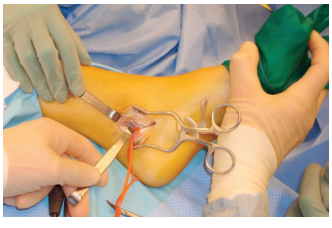

Figure 8: Posteromedial side of the left ankle. Overview to show the position of the left foot.

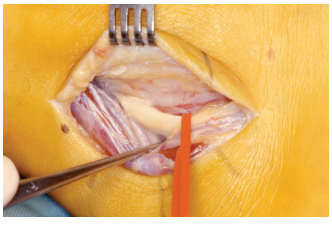

Figure 9: Posteromedial side of the left ankle. The neurovascular bundle is retracted with a red vessel loop, the forceps is inserted between the posterior tibial artery and veins (below the forceps) and the tibial nerve, which is the size of a pencil. The muscle belly in the lower aspect of the wound is a rare anatomical variation: an accessory soleus muscle

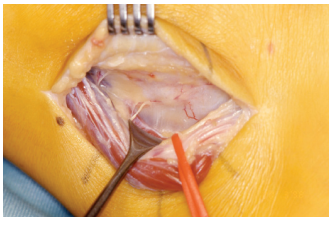

Figure 10: Posteromedial side of the left ankle. The neurovascular bundle retracted with a hook. Deep in the wound the FHL tendon-sheath is visible.

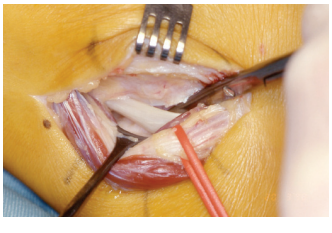

Figure 11: Posteromedial side of the left ankle. After opening its sheath the FHL tendon is presented in the wound

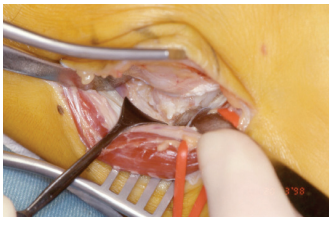

Figure 12: Posteromedial side of the left ankle. A spiky Stieda's process is visible deep of the FHL tendon, above the two hooks

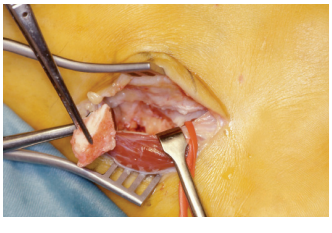

Figure 13: Posteromedial side of the left ankle. The triangular bony fragment ("os trigonum") is chiseled off of the posterior aspect of the talus.

In the literature 25 articles can be found that have studied the surgical treatment of PAIS and FHL tendinopathy in a total of 308 dancers (355 ankles).[12] The largest case series of operative treatment of PAIS describes the results in 39 dancers (60 ankles).[19]
This study aims to describe retrospectively the outcome of open operative treatment of PAIS and FHL tendinopathy in a large cohort of dancers, regarding results and post-operative morbidity, to establish a benchmark for future reference. To our knowledge this is the largest cohort of consecutive cases of PAIS and FHL tendinopathy in dancers operated on by a single orthopaedic surgeon.

Methods

Patient population: Consecutive patients operated on for PAIS and FHL tendinopathy were identified using hospital records of ankle surgeries performed by the first author between 1989 and October 2016. Matching patient files were then retrieved to filter surgeries performed in dancers only. Endoscopic surgeries were excluded and described in a separate article.[20]
Two ankles in the same patient were described and analysed as two separate procedures. Any secondary procedure due to failure of a previous procedure was excluded, but, if the first surgery was performed by the first author, the second surgery was described separately.
The study was approved by the medical ethics board of the hospital and conducted in accordance with the declaration of Helsinki.

Determination of patient characteristics: Patient characteristics, signs and symptoms, and follow-up were extracted from the clinical files. Patients were considered professional dancers if they were or had been enrolled in a vocational dance academy. Primary dance style was defined by the phrasing of the patient.

Operative characteristics: were derived from operative reports. Duration of the procedure was divided by two in cases of bilateral surgery on the same day. Patient characteristics and medical history were recorded at the initial presentation. Clinical findings were recorded at the appointment at which the decision for surgery was reached. All patients were operated on after they had failed at least six months of conservative treatment, including NSAIDs, orthotics, and physiotherapy, usually prescribed by the referring physician, otherwise started by the authors. Post-operatively the dancer-patient used a compression dressing for two days, and was allowed to bear weight as tolerated. When the intra-cutaneous sutures were removed after two weeks, vigorous mobilization of dorsiflexion and reconditioning were started, using a dance-specific, graded rehabilitation schedule, and usually supervised by a specialized physiotherapist.[21]

All symptoms that deviated from a normal course of rehabilitation and could be traced back during follow-up to the surgery were considered as complications. Follow-up time was defined as time to discharge from follow-up, and was measured in days.

Definition of outcome: Outcomes were scored at the day of discharge from follow-up. Post-operative success rate was defined by a patient's satisfaction score ranging from 1-5 (1, much worse; 2, worse; 3, the same; 4, better; 5, excellent) comparing pre- and post-operative situation at the date of discharge from follow-up. The scores were extracted independently from the clinical files by the second author.

Analyses: Differences between groups were calculated using chi-square tests for categorical variables. Survival analysis was performed using a Kaplan Meier curve with a log-rank test to look for a possible difference between patients with and without FHL tendinopathy. All analyses were performed using SPSS 22.0 (SPSS, IBM corp).

Results

Identification of procedures: In the hospital records 242 procedures for PAIS and/or FHL tendinopathy were found, affecting 193 patients. After exclusion of 52 procedures for various reasons, 190 procedures (148 patients) were included in the present study (Figure 14).

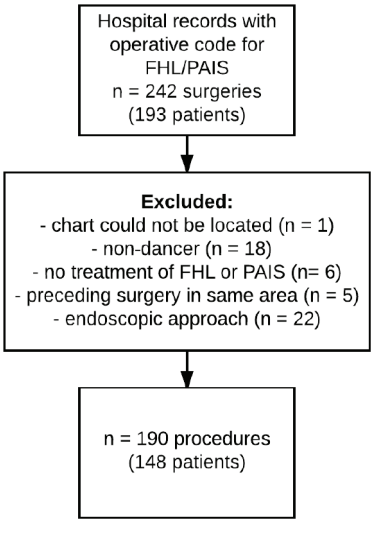

Figure 14: Flow diagram of patient inclusion

Population characteristics: The median age of the studied population was 19 years (IQR 16-22 years), and 82.1% of the patients were female. Most functioned on a professional level in one style or another of theatrical dance. All baseline characteristics can be found in Table 1.

Table 1: Baseline characteristics	Procedures (n=190)
Age in years median(IQR)	19 (16-22)
Female sex n(%)	156/190 (82.1)
BMI median (IQR)	20.5 (18.5-21.9)
Current smoker n (%)	26/160 (16.3)
Professional dancer n (%)	144/190 (75.8)
Age start dancing in years median (IQR)	6 (4-8)
Hours of dance a week median (IQR)	13.5 (6.5-20)
Primary dance style n (%)	
- Classical ballet	85/185 (45.9)
- Modern/jazz	64/185 (34.6)
- Show/musical	16/185 (8.6)
- Ballroom	14/185 (7.6)
- Other (folklore, urban)	6/185 (3.2)

BMI: body mass index, IQR: interquartile range. Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses. Continuous variables are displayed as medians with interquartile ranges (IQR).

Signs and symptoms: Of the 190 procedures, 57 (30%) were performed for FHL tendinopathy, 83 (43.7%) for PAIS, and 50 (26.3%) for a combination of these. Patients with PAIS presented with pain in the posterolateral aspect of the ankle, whereas patients with FHL tendinopathy presented with pain postero-medially. Not surprisingly, patients with a mixed diagnosis displayed a mixture of symptoms (Table 2).

Surgical approach: In isolated cases of PAIS a lateral approach was used; in other cases a medial approach was used (Table 3). Median operating time per procedure was 34 minutes (IQR: 30-40) for the lateral approach and 44 minutes for the medial approach (IQR 35-55). Specific findings during the surgeries included three cases of a duplicate os trigonum and three cases of a tendon ganglion of the FHL. Furthermore, an accessory soleus muscle was seen in five cases (see figure 9). A muscle belly that extended distally and may thus give rise to the "cork in bottle" phenomenon was described in 77.7% of cases. Ten patients needed FHL tendon repair, seven of whom presented with a triggering hallux (see Figures 15-16).

Table 2: Signs and Symptoms	FHL tendinopathy n = 57	PAIS n = 83	Both n = 50
Preceding trauma n (%)	6/57 (10.5)	22/82 (26.8)	9/44 (20.5)
Provocation of complaints n (%)			
▪ demi-plié	16/22 (72.7)	20/27 (74.1)	15/19 (78.9)
▪ tendu/pointe work	33/33 (100)	63/64 (98.4)	28/32 (87.5)
Punctum maximum of pain n (%)			
▪ posteromedial	26/36 (72.2)	7/47 (14.9)	12/21 (57.1)
▪ posterolateral	4/36 (11.1)	36/47 (76.6)	5/21 (23.8)
▪ both	1/36 (2.8)	1/47 (2.1)	-
▪ elsewhere	5/36 (13.9)	3/47 (6.4)	4/21 (19.0)
Pain with n (%)			
▪ plantar flexion test	7/27 (25.9)	34/67 (50.7)	6/16 (37.5)
▪ ankle McMurray test	10/46 (21.7)	71/77 (92.2)	28/38 (73.7)
▪ applying pressure medially	53/54 (98.1)	30/78 (38.5)	38/45 (84.4)
▪ applying pressure laterally	18/43 (41.9)	76/78 (97.4)	27/41 (65.9)

Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses.

Table 3: Operative characteristics	Medial approach n = 104 (%)	Lateral approach n = 86 (%)
Operation side:		
▪ right	51/104 (49.0)	43/86 (50.0)
▪ left	53/104 (51.0)	43/86 (50.0)
Bilateral surgery:		
▪ in one procedure	32/104 (30.8)	32/86 (37.2)
▪ in two procedures	23/104 (22.1)	6/86 (7.0)
Operation time in minutes (median, IQR)	44 (35-55)	34 (30-40)

Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses. Continuous variables are displayed as medians, with interquartile ranges (IQR)

Outcome

Follow-up information was available for 185 of the 190 procedures (97.4%). In 168 cases (90.8%), patients described the post-operative result as "better" or "much better" when compared to the pre-operative situation (Table 4). When operative success was defined as

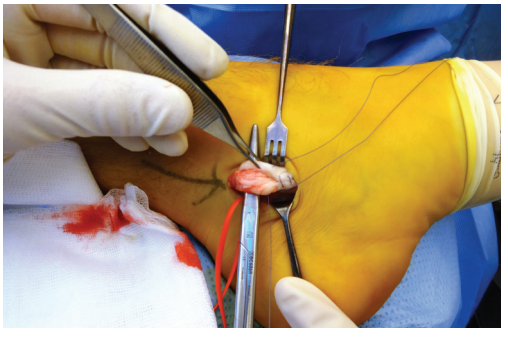

Figure 15: FHL tear

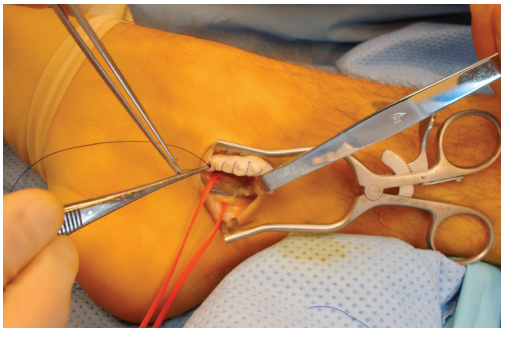

Figure 16: FHL tear sutured

"all patients that scored better or much better," reported smokers experienced less operative success (77% vs 94%, p = 0.005, data not shown). There were 24 minor transient complications (13%, Table 4), the presence of which neither required re-intervention nor influenced the post-operative results (90.6% success rate within patients without complication vs 91.7% success rate in patients with complication, p = 0.87). Smokers did not experience more wound infections when compared to non-smokers (3.8% vs 2.2% respectively, p = 0.63, data not shown). Return to dance was not systematically documented in the patient files. Patients visited the outpatient clinic according to protocol: two weeks, six weeks, three months, and half a year post-operatively or longer if needed. Median follow-up time was 157 days (IQR 91-245 days). Dancers operated via a lateral approach had a significantly shorter median follow-up time (lateral 113 days vs 190 for medial approach, p = 0.005, Figure 17). In spite of this shorter follow-up time there was no difference in end result between the lateral and medial approach (p = 0.24, data not shown). Operative tendon repair (see Figures 15-16) did not influence post-operative outcome (100% vs 90.1% operative success for tendon repair cases and non-tendon repair cases respectively, p = 0.30, data not shown).

Discussion

This study contains the world's largest consecutive case series of dancers surgically treated for PAIS and /or FHL tendinopathy by the traditional open operative method. We found a high success-rate (90.8%) for this operative method, with only minor complications that did not influence outcome during follow-up.

The success-rate described in the present study compares favorably with the literature to date, in which 89% good and excellent results, and 0.8% serious complications were reported. We found 13% minor transient complications in our cohort, of which none were serious.

Table 4: Surgical Outcome	Medial approach: n = 101 (%)	Lateral approach n = 84 (%)
General outcome		
▪ much worse	-	-
▪ worse	1/101 (1.0)	1/84 (1.2)
▪ same	8/101 (7.9)	7/84 (8.3)
▪ better	26/101 (25.7)	33/84 (39.3)
▪ much better	66/101 (65.3)	43/84 (51.2)
Complications	24/185 (13)	
▪ transient neurapraxia		
of which tibial nerve	6/101 (5.9)	-
of which sural nerve	-	9/84 (10.7)
▪ superficial wound infection	2/101 (2.0)	2/84 (2.4)
▪ posttraumatic dystrophy	2/101 (2.0)	-
▪ tarsal tunnel syndrome	1/101 (1.0)	-
▪ not otherwise specified	1/101 (1.0)	1/84 (1.2)
Median follow-up time in days (IQR) *	190 (122-298)	113 (74-192)

* defined as the time to discharge from follow-up. Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses. Continuous variables are displayed as medians, with interquartile ranges (IQR).

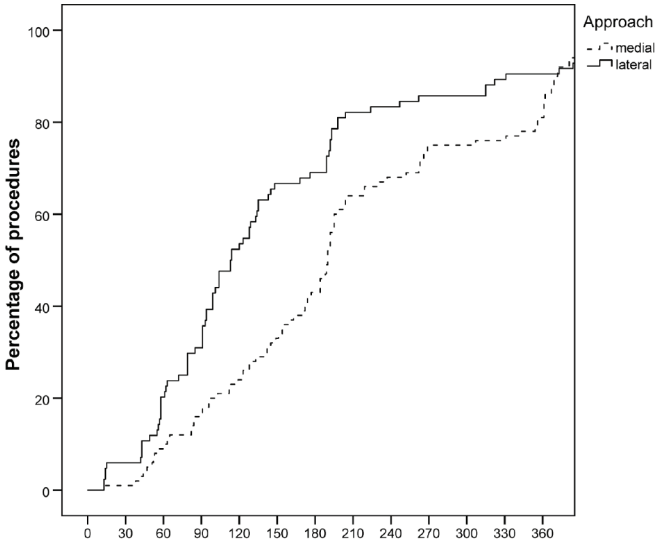

Figure 17: Kaplan Meier survival curve of follow-up time for lateral and medial approaches.
X axis cut off at 1 year post-operatively.

We described a total of 31 patients who underwent bilateral surgery with one procedure. We found these bilateral approaches to be well tolerated by the patients. Moreover, as rehabilitation time is an important factor to consider in professional dancers, this enabled the dancer to go through the negative effects of the surgery only once. Most patients were non-smokers. We found evidence for a negative effect of smoking in this cohort, whereas smoking was actively discouraged in all patients. This is not a surprising finding as smoking is a known cause of impaired wound healing. Furthermore, we found a difference in time to discharge from the outpatient clinic between patients operated on medially when compared to patients operated on laterally. Possible explanation for this is the larger amount of dissection (crossing more anatomical layers, like the ligamentum laciniatum and the tarsal tunnel) that is required to protect the neurovascular bundle in the open posteromedial approach as compared to the open postero-lateral approach. More dissection implies a larger subcutaneous wound, more recovery time, and more scar tissue.

Diagnosis of PAIS and FHL tendinopathy can usually be made based on simple physical signs and symptoms, complemented by X-ray examination for bony impingement. We found a pattern of postero-medially located signs and symptoms in FHL cases and postero-laterally located signs and symptoms for PAIS cases. Unfortunately, due to the retrospective nature of this study, the diagnostic accuracy of the different signs and symptoms could not be definitively determined. Based on the available information presented in this study, the ankle McMurray test may be more specific than the plantar flexion test for PAIS.
We identified two procedures that can be considered operative failures, as they exhibited worse complaints as compared to the pre-operative situation. The first case was a smoking 29-year old classical ballet student with FHL tendinopathy who for reasons unknown to the authors unfortunately did not benefit from the surgery and left the outpatient clinic dissatisfied. The second failure was a 23-year old modern/jazz student operated for bony impingement based on an enlarged posterior process with minor complaints of the medial aspect of the ankle at first presentation. This patient was operated with a lateral approach, resulting in operative failure because of persisting FHL complaints. After re-operation with FHL tendon release, she reported a result that was "much better" as compared to pre-operatively. This case can thus be considered initial misjudgement of the surgeon.

Including the case described above, three patients were operated on twice on the same ankle. The second re-intervention was in a 15-year old classical ballet student with a bony impingement based on an enlarged posterior process. She reported a "better" situation as compared to pre-operatively, but still was persistently symptomatic. X-ray examination

revealed that the removal of the hypertrophic posterior process had been insufficient. This patient was operated on again with good results. The third re-operation entailed an 11-year old show/musical dance student who was initially operated on because of FHL tendinopathy, with excellent results. A year later the patient presented with PAIS complaints based on a newly developed hypertrophic posterior process that had not been present on the earlier X-rays. This patient was operated on again, with excellent results. The ankle in question was the only one included twice in the study, as the re-operation was considered a new case based on a new diagnosis.

Limitations of this study are mainly due to its retrospective nature. Firstly, the surgical outcomes are scored based on description of the post-operative status in the patient files. This may lead to overestimation of positive results, as the surgeon could have highlighted positive results and ignored negative ones in his notes. However, as this study included all patients and the second author independently evaluated all patients, the influence of this potential source of bias are considered to be minor. Secondly, functional outcome in terms of range of motion and return to dance were not described systematically in all patients, and therefore could not be taken into account. Future studies should further clarify the course of rehabilitation, preferably in a prospective manner, focussing on the short-term and dance-specific results, as these are under reported in the literature.

Thirdly, long-term follow-up was unavailable in the current study, thereby prohibiting any conclusions on long-term outcomes and recurrent symptoms, especially in FHL patients. Fourthly, this cohort can be considered a tertiary referral clinic population, and therefore extrapolation to other clinics and surgeons should be approached with caution. The procedure was carried out on a regular basis by this surgeon, which could impel the success-rate and mask the fact that it is a delicate, minimally invasive procedure. A well placed one inch incision usually will do. Surgeons not performing this operation regularly may be tempted to make a larger incision and exposure, un-necessarily jeopardizing the end-result. However, the whole learning curve of this surgeon was encompassed in the results and we found no evidence for a time-dependent effect of the success-rate.

Finally, although the demands of plantar flexion of the foot and ankle complex can be considered highest in ballet when compared to other dance styles, the outcome can be considered representative for dancers in general, since most dance styles were represented in this cohort.

This retrospective cohort study confirms earlier outcomes in smaller series of a high success rate for the traditional open approach to PAIS and FHL surgery. Future studies, preferably with a prospective design, should systematically report on dance-specific functional outcomes with pre- and post-procedural pain scales to quantify results, and should include measures of short-term follow-up, as the post-operative morbidity in the short term is insufficiently studied.

Conclusion

The open surgical treatment of PAIS and FHL tendinopathy in dancers has a high success-rate, and can be considered a successful standard operative approach. More detailed information is needed about dance-specific outcomes and the early post-operative course.

Acknowledgement

We thank Han Haitjema for taking the photographs of the dancer (the second co-author. Figures 1-5).The operation photographs were taken by George Patho, hospital photographer of Haaglanden Medical Centre in The Hague. All photographs are published with permission of the dancers involved.

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