Performing arts medicine with a focus on Relevé in Dancers

Rietveld, A.B.M.

Relevé in a normal dancers' foot

Overview of the left foot, ready for open release of the flexor hallucis longus tendon sheath and removal of an os trigonum via the posteromedial side

PART 2 (chapters 7-9)

Results of conservative and operative treatment of Limited and painful 'Relevé' in Dancers due to Posterior Ankle Impingement Syndrome (PAIS) and Flexor Hallucis Longus (FHL) Tendinopathy: *Dancers' Heel and Dancers' Tendinitis*

Chapter 7

Results of Treatment of Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in Dancers: A Systematic Review

A.B.M.(Boni) Rietveld
Fleur M.T. Hagemans
Saskia Haitjema
Thomas Vissers
Rob G.H.H. Nelissen

In press: Journal of Dance Medicine and Science, 2017

Results of Treatment of Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in Dancers: A Systematic Review

7

Abstract

Dancing on pointe and relevé require extreme plantar flexion of the talo-crural joint. Hence, these positions may lead to Posterior Ankle Impingement Syndrome (PAIS). PAIS often coincides with flexor hallucis longus tendinopathy (FHL tendinopathy, or *Dancers' tendinitis*). Both injuries can appear in isolation as well. The goal of this review is to evaluate the results of conservative and operative treatment (both open and endoscopic) of PAIS and/or FHL tendinopathy in dancers, and the available levels of evidence. It also offers an insight into the history of dance medical publications on this subject. In October, 2016, a systematic search of PubMed, Embase, COCHRANE, CINAHL, Web of Science, and (in French) ScienceDirect databases was undertaken. Five hundred and seventy-six publications were found, of which 74, including 36 expert opinion reviews, described treatment in dancers, starting with A.J. Howse in 1972 and W.G. Hamilton in 1977. A total of 27 reported the results of operative treatment in 376 ankles (344 open, 32 endoscopic) in 324 dancers. The outcome was good to excellent in most cases (89%). Mean period of return to dance for all surgeries combined (PAIS and/or FHL tendinopathy, open and endo) was 11 weeks (range: 4-36 weeks), and for isolated FHL tendinopathy 16 weeks (range: 8 - 36 weeks).

Only six publications reported the results of conservative treatment in 33 ankles (13 PAIS, 20 FHL tendinopathy) of 28 dancers, not allowing any evidence-based recommendations.

Most studies failed to include dance-specific baseline characteristics, like dance style and level of participation.

We concluded that only retrospective studies with levels of evidence four and five show that operative treatment for PAIS and / or FHL tendinopathy is successful with few complications. Studies on conservative treatment hardly exist and are of low quality.

Since isolated PAIS, PAIS combined with FHL tendinopathy, and isolated FHL injuries appear to be different pathological entities, more research is needed to find out in which cases early operative management should be considered or avoided, taking into account demography, dance type, and level of participation. The same applies to defining the place of endoscopic surgery in dancers, and being able better to predict which pathology is likely to produce worse outcomes or delay in return to dance. Future research should have a prospective design, including dance-specific outcome scores both pre- and post-treatment. Furthermore, preferably a prospective randomized controlled design should be used to compare different conservative and operative treatment options.

Introduction

In a dedicated dance-medical orthopaedic referral center 454 of 587 injuries (77%) in 345 dancers involved the lower extremity. The highest proportion (27%) involved the ankle. More than half of those were Posterior Ankle Impingement Syndrome (PAIS)or flexor hallucis longus tendinopathy (FHL tendinopathy).[1] A similar pattern is seen in other recent studies on dancers' injuries: the highest numbers of injuries in professional and pre-professional dancers (mainly ballet) concern the foot and ankle, the commonest being ankle sprains, followed by PAIS and FHL tendinopathy.[2;3] Given the frequency of PAIS and FHL tendinopathy in dancers, knowledge of their optimal treatment in dancers is mandatory. That is why we decided to perform this systematic review.

Dancing *on pointe* occurs predominantly in ballet (see Fig.1). Relevé is an ankle-foot position typical of all forms and styles of dance around the world, and is required in virtually every choreography (see Fig.2). In dance the ankle is frequently, actively, and with prolonged forced taken into extreme plantar flexion. This means that the foot-ankle joint complex is fully weight bearing at the end range of joint motion ("close-pack"). Both in relevé and on pointe forces are transmitted directly through the contacting bones, with neither intrinsic shock damping by compensatory joint motion nor extrinsic shock absorption by the shoe or the floor. This leads to repetitive peak stress on the contacting bony structures in the back of the ankle and may contribute to the frequency of PAIS in dancers.

Figure 1: On pointe

Figure 2: Relevé

In some sports extreme plantar flexion of the ankle is required periodically and suddenly in a passive manner (by external force, e.g., soccer during certain forms of kicking) or briefly in an active manner (e.g., gymnastics and other artistic sports), but never in the controlled, persistent, extreme, active, and fully weight bearing manner as is so frequent in dance.

In kicking a ball the talo-crural and subtalar joints are non-weight-bearing; hence, there is no tendency of the talus (talo-crurally) and calcaneus (subtalarly) to slide posteriorly, adding to the impingement. Secondly, in kicking the calcaneus is not pulled up by the triceps surae. That this is important is biomechanically logical and is illustrated by the fact that in PAIS testing (plantar flexion test) the pain will mainly be provoked if the calcaneus is pressed up simultaneously. Of course in gymnastics and other "artistic" sports, as well as in many ADL activities, this happens briefly, but again, the persistent, repeated combination of these factors is unique to dance. As a consequence PAIS is a typical and common dancers' injury, and sometimes is referred to as dancers' heel.[4]

In dancers FHL tendinopathy, posteriorly and plantarly to the medial malleolus and sustentaculum tali, regularly coincides with PAIS (estimates vary between 26% and 63%),[5;6] and sometimes is referred to as dancers' tendinitis.[7;8] The etiology of FHL tendinopathy in dancers is not fully understood. It may be related to anatomical deviations,[9;10] faulty dance technique,[11] and possibly FHL activity in certain dance positions and jumps.

Successful operative treatment at a youthful age and/or a healthy worker effect (only the strongest persist) were the suggestions of these authors to explain the fact that they found the percentage of ankle problems to diminish with age from 27% in a group of dancers of all ages (n = 345), half of them having PAIS and/or FHL tendinopathy, to 3% in dancers 45 years of age and older.[1]

Conservative management of these diagnoses for at least 3 months is likely to be the first choice of dancers and their doctors alike. Non-surgical modalities may include correction of dance technique and alignment, a period of relative rest and/or modification of (dance) activities, physical therapy,[12] and arch supports.[13] Only in selected cases of PAIS (soft tissue impingement rather than bony impingement), not in FHL tendinopathy, injections (local anesthetic with corticosteroid) may be beneficial.[5]

If conservative treatment for PAIS and/or FHL tendinopathy fails, surgery is recommended. This can be done via an open procedure, with either a medial or a lateral approach. The medial

approach is used in isolated FHL tendinitis or in cases with a combination of FHL tendinitis and (bony) PAIS. The lateral approach is used when the diagnosis is limited to posterior ankle impingement by a bony impediment.[5;9;10;14] In 2000 a hindfoot endoscopic technique was introduced by van Dijk.[15-18]

One of the pioneers of orthopedic dance medicine is E. Thomasen. In his book *Diseases and Injuries of Ballet Dancers*, published in 1982, he describes operative treatment of FHL tendinopathy and/or posterior impingement of an os trigonum or hypertrophic posterior process of the talus (Stieda's process).[10] His extensive description includes details on anatomy and symptoms in 72 ankles of 69 ballet dancers, making it the largest case series to date, and still covers about 20% of all dancers with PAIS and FHL tendinopathy described in the literature (see Table 2). In the introduction to his book Thomasen states that these injuries are peculiar to dancers, because dancers' positions and movements are different from "normal" positions and movements in sports and daily life. Also, A.J. Howse emphasized in 1972 that an os trigonum causes symptoms only when the foot is forced to do something abnormal.[19]

The preparation of this review offered an insight into the history of dance medical publications on this subject: thirty-six expert opinion publications mentioned conservative or surgical treatment of posterior ankle problems in dancers.[8;12;14;19-51] These opinions were relevant, but mostly empirical, lacking original research and evidence, although they usually included a brief review of the available literature, referencing publications that were also found and documented in our systematic search. A. J. Howse in 1972 was the first author to describe os trigonum syndrome in dancers and the result of surgical treatment: "excision of the extra bone relieves the symptoms."[19] W. G. Hamilton was the first author to describe FHL tendinopathy in dancers, coined by him as "dancers' tendinitis" in 1976.[7;8] G. J. Sammarco in 1979 was the first to describe triggering of the hallux in dancers due to FHL tendinopathy.[52]

Given the specific and different demands of dance compared to sports, studying the treatment outcome for PAIS and FHL tendinopathy in dancers specifically is of paramount importance. The results in sports cannot be extrapolated to dance. The goal of our review is, therefore, to study systematically the current medical scientific literature on the results of conservative and operative (both open and endoscopically) treatment for PAIS and/or FHL tendinopathy in dancers, and evaluate the available levels of evidence.

Methods

Without restriction of date a systematic search in English and French only was performed in October, 2016, using PubMed, MEDLINE, Embase, Cochrane, CINAHL, Web of Science (for English literature), and ScienceDirect (for French literature) databases. Our search criteria encompassed anatomy (e.g., ankle, talo-crural, talus, os trigonum, Stieda's process, flexor hallucis longus), type of injury (primarily ankle impingement, tendinitis, tendinopathy, Shepherd's fracture, and trigger toe), and type of activity (dance). Each search term included all possible synonyms and word-roots. The type of treatment was not included to prevent undesirable and unnoticed exclusion. For the same reason the criterion posterior was avoided. Dancers were specified as persons who, either as an amateur or as a professional, danced at least 3 times per week in an organized manner, regardless of age, sex, nationality, or dance style.

The complete systematic review protocol was recorded under number 48258 at Prospero, the international prospective register of systematic reviews (http://www.crd.york.ac.uk/prospero). The search strategy, including all detailed search criteria, like MeSH terms, can be found and downloaded via http://www.crd.york.ac.uk/PROSPEROFILES/48258_STRATEGY_20161020.pdf.

Two readers (first and second author) independently and blinded selected the articles, using the principles of the Prisma statement,[53] and five pre-specified eligibility criteria:

1. all studies and articles of all levels of evidence, from expert opinions and case reports to randomized clinical trials and systematic reviews, which report, but are not necessarily limited to, posterior ankle problems, more specifically PAIS and FHL tendinopathy, including, but not necessarily limited to, dancers.

From this first survey we selected all articles describing:

2. dancers only, or reporting on dancers as a separate group;
3. any type of treatment of PAIS and/or FHL tendinopathy in dancers;
4. results of conservative treatment of PAIS and/or FHL tendinopathy in dancers;
5. results of operative treatment, both open and endoscopic procedures, in dancers.

Conflicts of opinion regarding articles were referred to a third reviewer (third author). All three reviewers were MD's, experienced in dance medicine. The selected articles were further rated according to their study design and their level of evidence according to "Levels of Evidence for Primary Research Questions" (See Table 1).[54;55]

Table 1: Study Type: Therapeutic—Investigating the results of a treatment.

Question: Does this treatment help? What are the harms?
Level 1: Randomized controlled trial (a meta-analysis of RCT's is the highest level)
Level 2: Prospective cohort study or observational study with dramatic effect
Level 3: Retrospective cohort study or case-control study (comparative)
Level 4: Case series or historically controlled study (non-comparative)
Level 5: Mechanism-based reasoning (including expert opinions and case reports)

Adapted from Instructions for Authors of the Journal of Bone & Joint Surgery (JBJS)

The quality of the included publications was critically appraised using the system of the Grading of Recommendations Assessment, Development and Evaluation working group (see: www.gradeworkinggroup.org).[56] We checked demographic data, type of injury (soft tissue or different types of bony impingement[57] and/or FHL tendinopathy), type of conservative treatment or operation, duration of follow-up time, outcome measures (imprecision, publication bias, indirectness), heterogeneity or inconsistency of results between studies, and the effect size. Brief descriptive statistics of case reports were included, but for analysis of qualitative and quantitative outcome we used level of evidence four and higher studies only

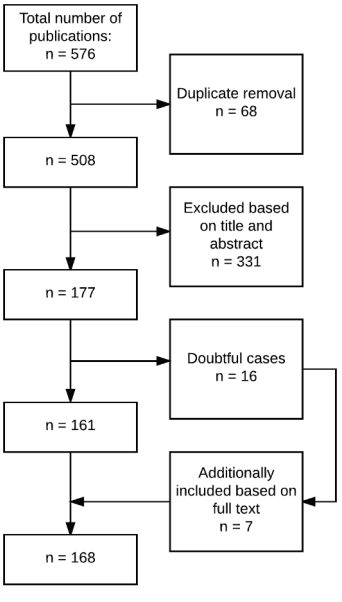

Figure 3: Flowchart total search

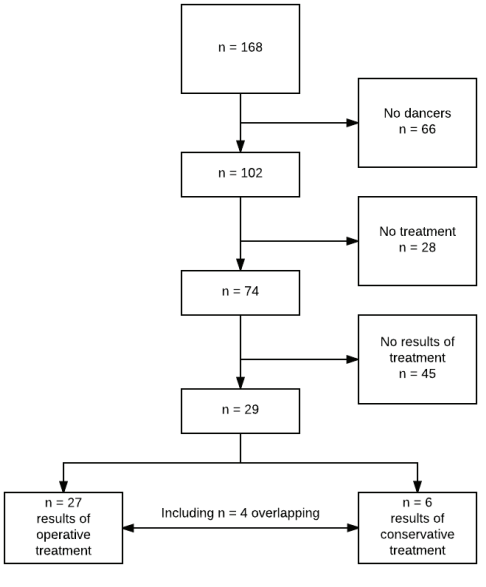

Figure 4: Flowchart final selection

Results

Our search resulted in 576 publications. After extracting 68 duplicates, the remaining 508 publications were scored to conform to the first eligibility criterion (see Fig. 3 flowchart). The resulting 168 included publications were scored to conform to eligibility criteria 2-5 (see Fig. 4 flowchart). In 117 instances the full text was obtained and studied, because title and abstract alone were not sufficient to determine eligibility (data not shown).

Results of operative treatment of PAIS and/or FHL tendinopathy in dancers: The results of operative treatment in dancers were reported in 27 publications: nine case reports,[15;52;58-64] 14 case series,[5;9;65-76] two cohort studies,[77;78] one expert opinion,[79] and one systematic review.[80]

One expert opinion review was initially included but had to be excluded in the second instance due to publication bias, since the same groups of dancers were also studied in depth in 2016 in one of the two cohort studies.[77;79]

The systematic review was excluded to avoid duplication of some articles, but we decided to use it in the discussion to give us the opportunity to check for completeness of our search and to compare our findings.[80]

An overview of dancers with surgical treatment of ankles for PAIS and/or FHL tendinopathy in the remaining 25 articles, level of evidence four and five observational studies only, is shown in Table 2.

Table 2: Numbers of operated dancers and ankles found in 25 * of the 27 publications reporting the results of operative treatment of PAIS and / or FHL tendinopathy in dancers, found in the search for this systematic review until October 1st, 2016

	Total		Open		Endo	
9 case reports	16	21	10	14	6	7
14 case series	266	313	257	303	9	10
2 cohort studies	42	42	27	27	15	15
Subtotal 14 case series and 2 cohorts	308	355	284	330	24	25
Total found in search (25 publications)	324	376	294	344	30	32
Thomasen's book:	69	72	69	72	0	0

* Two publications are used in the discussion only, and not included for analysis in this table: an expert opinion review article [79] reporting the same groups of dancers as in one of the two cohort studies, and a systematic review. [80]

Qualitative and quantitative outcome: For the analysis of qualitative and quantitative outcome, 14 case series [5;9;65-76] and two cohort studies[77;78] were available. Overall in these 16 articles the scoring of results was:

- Qualitative, using personalized scoring systems (e.g., excellent, good, fair, poor, symptom-free, pain-free, etc.): in 10 case series until 1999;
- Functional, such as return to dance or return to previous activity, in 12 case series and the two cohort studies;
- Quantitative, using validated general scoring systems, since 2002: in three case series[66;74;75] pre- and post-operative outcome scores were used, post-operative scoring in one case series.[70] One cohort study used pre- and post-operative quantitative scoring but did not separate dance and sports.[78] No author used a dance-specific outcome score.

We combined the scoring in 308 dancers and 355 operations of the 14 case series and two cohort studies, lumping together all different scoring systems (Table 3).

Table 3: Overall results of scoring of all qualitative and quantitative scoring systems combined in 308 dancers (355 operations) based on 14 case series and two cohort studies

Excellent	210	68%
Good	64	21%
Fair	20	7%
Poor	13	4%
Lost for follow up:	1	-
Stopped dancing for unrelated reasons:	4	-
Not specified *	7	-
Total	319	**

* One cohort study did not score dance and sports separately. [78]

** Most authors scored dancers, two authors (three different case series) scored procedures. Since it is impossible to separate those dancers that had bilateral procedures, the total number (319) includes 11 bilateral operations in 308 dancers. We found no report of bilateral procedures functioning differently or needing more time for rehabilitation.

Functional outcome: Functional scoring ("return to dance") was the primary outcome measure in 14 publications. Hamilton was the only author providing a dance-specific differentiation in return to dance: "barre exercises," "participation in class," and "return to full performance". [5] One publication distinguished between unspecified return to dance (7.8 weeks) and return to dance pain-free (17.7 weeks).[68] In the other studies definitions of return to dance were inconsistent or missing.

Combining the results of all series that scored functional outcome, regardless of the type of operation, we found 11 weeks as mean time to (unspecified) return to dance in general, with a

range from 4 to 36 weeks. Dancers with a combination of PAIS and FHL tendinopathy returned to dance in seven weeks, dancers with isolated FHL tendinopathy (without PAIS) in 16 weeks. Both groups were operated via an open posteromedial approach (see Table 4).

Table 4: Mean return to dance per pathology and per type of operation (14 case series and four series in two cohort studies)

	No of series	No of ankles	Mean RtD (weeks)	Range (wks)
All surgeries *	12	212	11	4 - 36
All surgeries **	13	253	13 **	4 - 96
All open surgeries *	9	191	11	4 - 36
All open surgeries **	*10*	*232*	*14* **	*4 - 96*
All endoscopic surgeries	3	21	10	6 - 20
All open PAIS (PL & PM)	6	133	11	4 - 24
Open PAIS&FHL (PM)	2	31	7	3 - 20
Open FHL (PM)	2	27	16	8 - 36
Open PL PAIS	3	28	12	4 - 24
Open PM PAIS	2	83	10	3 - 20
Endo PAIS	3	21	10	6 - 20

* in 5 studies either return to dance, or pathology, or procedure was not specified. One study (41 ankles) excluded (see **)

** one extreme 'outlier' (96 weeks RtD) in a series of 41 ankles included (see remark S6 in Table 6).

Endo: via endoscopic technique; FHL: flexor hallucis longus tendinopathy; PL: open via posterolateral approach; PM: open via posteromedial approach; PAIS: posterior ankle impingement syndrome; RtD: Return to Dance

Table 5: Included case reports (level of evidence 5) conforming to eligibility criterium nr. 5

Table 5: Included case reports (level of evidence 5) conforming to eligibility criterium nr. 5

	Year	Author	Dancers	Ankles	Dance	F/M	R/L	Age	Pathology	Procedure	FU	Result	RtD
1	1979	Sammarco	2	3	Ballet	2/0	1/2	23	FHL ('trigger toe')	Open PM	3 m	NS	12 w
2	1981	Garth	1	2	Ballet	1/0	1/1	21	FHL	Open NS	7 m	NS	not yet
3	1982	Quirk	2	3	Ballet	1/1	1/2	17	PAIS	Open PL	36 m	2 excellent	12 w
4	1985	Lereim	2	3	Ballet	1/1	2/1	20	FHL ('trigger toe')	Open NS	6 m	1 exc. 1 good	12&24w
5	2000	Van Dijk	1	2	Ballet	1/0	1/1	22	FHL&PAIS	Endo	30 m	1 excellent	8 w
6	2008	Almazan	1	1	Ballet	1/0	1/0	17	PAIS	Endo	NS	1 excellent	8 w
7	2009	Albisetti *	2/1 *	2/1 *	Ballet	2/1	NS	14	PAIS	Open NS / endo	NS	2 exc / 1 good *	6w/9w *
8	2010	Porter	1	1	Ballet	1/0	0/1	17	FHL	Open NS	NS	NS	NS
9	2013	Ahn	3	3	NS	NS	NS	NS	PAIS	Endo	NS	3 excellent	10 w
		Total	16	21	Ballet	10/3	7/8	19,7	FHL 4, PAIS 4, mixed 1	Open 5, endo 3, mixed 1	3 – 30 m		6–24w

F, female; FHL, flexor hallucis longus tendinopathy; FU, follow-up; M, male; m, months; NS, not specified; PAIS, posterior ankle impingement syndrome; Procedure: open PL/PM, open posterolateral (PL) or open posteromedial (PM) approach; RtD, Return to Dance; w, weeks. Result: this is our interpretation of the text in the case reports: excellent means completely symptomfree dancing at former level, good means symptomfree dancing at former level with slight pain afterwards, NS means not (yet) returned to dance at FU. * Albisetti: in all fields the two Open NS cases are mentioned first.

Case reports: Descriptive statistics of the nine case reports on open and endoscopic procedures for PAIS and FHL tendinopathy in dancers are shown in Table 5.[15;52;58-64]
Six case reports[15;58-60;62;64] produced a non-validated qualitative outcome, totaling nine dancers (12 ankles) who had a good to excellent result. In the other three case reports[52;61;63] the outcome in four dancers (six ankles) was not reported. None used outcome scoring.

Case series: We identified 14 case series (266 dancers, 313 ankles) that reported the results of operative treatment of PAIS and/or FHL tendinopathy in dancers, either via an open operation (12 series, 257 dancers, 303 ankles) or performed endoscopically (two series, nine dancers, 10 ankles).[5;9;65-76] See Table 6.
Some studies identified factors associated with higher success rates. In a retrospective review of 41 operations in 37 dancers, the surgical procedure was more successful in professionals compared to amateurs.[5] Furthermore, return to a full dance (professional classical ballet) schedule was shorter (5 months) after the operation for isolated posterior impingement than after the combined procedure for posterior impingement and FHL tendinopathy, or after the operation for isolated FHL tendinopathy only (both 6 months).[5] The largest case series of dancers (PAIS only: 39 dancers, 60 ankles) found better results in those below the age of 17 years at the time of surgery; in this younger group 86% (18/21) showed good to excellent results compared to 67% (12/18) in older subjects.[73] The dancers of the Swedish National Ballet were the fastest to return to full performance dancing (mean 7 weeks, range 5-10 weeks) after an open posteromedial approach for PAIS and FHL tendinopathy.[76] FHL tendon injuries in dancers versus non-dancers both yielded "consistently good results".[72]
In 2016 the most recent series appeared, describing 40 ankles in 38 dancers who underwent os trigonum excision via an open posteromedial approach with FHL tenolysis, with an excellent result in 95% of the cases and one ballet dancer who, although she returned to ballet and modern dance, was unable to return to her pre-injury level of pointe because of posteromedial scar tissue. The average time to return to unspecified dance was 7.9 weeks, and the time to pain-free dance was 17.7 weeks.[68]

Cohort studies: In two retrospective cohort studies a total of 42 ankles in 42 dancers was studied, comparing the results of open operative treatment of PAIS (27 ankles in 27 dancers) and endoscopic treatment (15 ankles in 15 dancers). There were no FHL tendinopathy cases in these studies.[77;78] had occurred. In four case series (a total of 52 cases: 19 open posterolateral and 33 open posteromedial in 44 dancers) we assumed there were no complications. However, this was not mentioned specifically.[9;67;72;81]

In the first cohort study[78] (open: five dancers in 16 patients; endoscopic: two dancers in 25 patients) comparison of outcome in the total seven dancers was impossible, since they were not studied in detail, except for "*return to their previous level of performance,*" which was not further specified. Additionally, five patients in the total group of 41 patients underwent anterior ankle clean-out, but it was not specified in which group and whether they were dancers.
The second cohort study compared the results after open (n = 22) and endoscopic (n = 13) excision of an os trigonum in high-level ballet dancers.[77] However, the groups were not comparable: the dancers in the open group were considerably younger and rehabilitation was different between the two groups. Three of 22 patients in the open group and one of 13 patients in the endoscopic group had concurrent lateral ligament reconstruction. Thirteen of 22 patients in the open group had FHL tendon decompression compared with two of 13 patients in the endoscopic group. Return to dance after open surgical treatment in the two cohort studies took considerably longer (mean 15.1 weeks) than average (mean 11.2 weeks, see Table 4). All dancers were asymptomatic with regard to their ankle at the final follow-up visit (12 months).
As the comparative nature of both retrospective, comparative cohort studies posed serious limitations for our research question, we downgraded them to level of evidence four instead of three and combined them with the 14 case series to evaluate the results of operative treatment in dancers (see Table 6).

Surgical complications: In the 14 case series and two cohort studies we counted 22 complications in 355 operations in 308 dancers. Therefore, the overall complication rate, regardless of the type of operation, was 6.2%. There were 21 complications in 330 open operations (5,9%), and one (transient sensory neuropraxia of the tibial nerve)[74] in 25 endoscopic operations (4%). Complication rates were 12.8% for open posterolateral, and 4.3% for open posteromedial operations (see Table 7).
All but three complications were minor, like hematomas, superficial wound infections, and transient neurapraxias of the tibial or sural nerve. The three more serious complications (0.85% of 355 operations) were one hematoma that had to be surgically revised after an open posteromedial operation, [70] one case with complex regional pain syndrome after an unspecified open operation,[66] and one permanent sural nerve injury after an open posterolateral operation[78] (NB: it was not specified whether this last case was in dance or sports). For all nine case reports, three case series,[69;75;76] and an additional three series in the two cohort studies[77;78] (a total of 91 cases, 63 open and 28 endo, in 89 dancers) it was stated that no complications

Table 6: Results of operative treatment, both via an open approach and endoscopically, of posterior ankle impingement and flexor hallucis longus tendinopathy in dancers (eligibility criterium nr. 5). Fourteen case series (S1-S14) and two cohort studies (C1a/b-C2a/b)

Table 6: Results of operative treatment, both via an open approach and endoscopically, of posterior ankle impingement and flexor hallucis longus tendinopathy in dancers (eligibility criterium nr. 5). Fourteen case series (S1-S14) and two cohort studies (C1a/b-C2a/b)

Nr	Year	Author	Type of Dance	Dancers	Ankles	F	M	R	L	Age	Pathology	Surgery
			Level of participation								(number of ankles)	
a	1982	Thomasen †	Ballet	46 (34) ††	36	30	16	ns	ns	26	PAIS OT	Open PL
b	1982	Thomasen	Ballet	16 (10)	10	11	5	ns	ns	NS	PAIS PP	Open PL
c	1982	Thomasen	Ballet	52 (25)	26	38	14	ns	ns	25	FHL	Open PM
S1	1982	Hamilton	Ballet	16	21	10	6	ns	ns	26	PAIS & FHL	Open mixed
S2	1986	Brodsky	Ballet	6	8	5	1	5	3	21	PAIS	Open PL
S3	1991	Wredmark	Ballet	13	14	9	4	9	5	20	PAIS & FHL	Open PM
S4	1992	Marotta&Micheli	Ballet	12	15	ns	ns	7	8	23	PAIS OT	Open PL
S5	1996	Kolettis&Micheli	Ballet	13	13	13	0	4	9	20	FHL	Open PM
S6	1996	Hamilton (S6)	Ballet 30 Modern-Jazz 7	37	41	22	15	19	22	23	FHL 6, PAIS 9,	Open PL 6,
			Prof 31, amateurs 6								Mixed 26	Open PM 35
S7	1997	Heim & Siev-Ner	Ballet	9	9	ns	ns	ns	ns	NS	PAIS OT	Open PL
S8	1998	Sammarco	Ballet	13	14	13	0	ns	ns	20	FHL	Open PM
S9	1999	Spicer & Howse	Ballet, stud. & prof.	39	60	30	9	ns	ns	12-48	PAIS	Open PM
S10	2002	Labs	Mixed professional:	24	24	20	4	ns	ns	22	18 PAIS,	Open PM
			14 ballet, 7 revue, 3 jazz								6 combined	
S11	2007	Tey (S11)	Ballet professional	3	4	3	0	ns	ns	20	PAIS	Endo
S12	2014	Vila (S12)	Ballet professional	6	6	4	2	ns	ns	25	5 PAIS, 1 combined	Endo
S13	2015	Coetzee	NS	37	44	32	5	ns	ns	NS	PAIS OT	Open PM 36
												Open PL 8
S14	2016	Heyer & Rose	Ballet 36, modern 3, salsa 1	38	40	37	1	20	20	19,2	23 PAIS, 17 combined	Open PM
			38 (pre-) prof, 2 amateurs								FHL (triggering)	
C1a	2013	Guo (C1)	NS	5	5	ns	ns	ns	ns	NS	PAIS OT	Open PL
C1b			NS	2	2	ns	ns	ns	ns	NS	PAIS OT	Endo
C2a	2016	Ballal (C2)	Professional ballet	22	22	13	9	ns	ns	17,6	9 PAIS, 13 combined	Open NS
C2b			Professional ballet	13	13	7	6	ns	ns	20,4	11 PAIS, 2 combined	Endo

Nr	Year	Author	Type of Dance	Dancers	Ankles	F	M	R	L	Age	Pathology	Technique
			Level of participation								(number of ankles)	
	Total (excl. Thomasen):		Ballet: 245	308	355	218	62	64	67	21,3	PAIS: 243	PM: 255
			Modern-jazz: 13	Open 284	Open 330	78%	22%	49%	51%	Open 21,1	FHL: 38	PL: 53
			Revue: 7, salsa: 1	Endo 24	Endo 25	ns:	28	ns:	224	Endo 21,6	Mixed: 74	Open NS: 22
			NS: 44 'dancers'									Endo: 25

AOFAS: score of the American Orthopaedic Foot & Ankle Society; F: female; FFI: Foot Function Index; FHL: flexor hallucis longus tendinopathy; FU: follow-up; funct.: functional, using 'return to dance'; M: male; NS: not specified; PL: open via posterolateral approach; PM: open via posteromedial approach; OT: os trigonum; PAIS: posterior ankle impingement syndrome; PP: hypertrophic posterior process of talus; Qual: qualitative, e.g. using anchor questions;
Quant: quantitative, using scoring systems, e.g. AOFAS; RAND: Veterans RAND 12 Item Health Survey Mental and Physical Health; RtD: Return to Dance; VAS: visual analogue scale.
Age: in case of more than one patient the average age is taken. The total age is the average age of all dancers in all case reports, series and cohort studies, as far as specified (N=175). It is the same for open and endo.
† nrs a, b and c: since our search did not find Thomasen's book, we do not include his three case series (all open technique, 69 dancers, 72 ankles; see introduction and discussion), but we discuss them and do show them in this table 6, numbered a,b and c.
†† Dancers: the total number of dancers seen with the diagnosis (the number of operated dancers is given in brackets).

S6 Hamilton 1996: the 'Return to Dance' data indicate return to full performance and may not be representative, since they include amateur dancers and an outlier (one dancer who needed an additional operation after a year and finally had an excellent result). In an attempt to correct this the first author contacted dr.Hamilton, ...

Table 6: continued

Table 6 continued

Nr	FU months	Score	Result	Return to Dance (RtD) or previous level of participation
a	NS	Qual	33 painfree	NS
b	NS	Qual	All good / perfect	NS
c	NS	Qual	All but one symptom-free	NS
S1	NS	Qual & Funct	15 good, 1 fair, 1 lost	12-32 weeks
S2	84	Qual & Funct	All good	Mean 10 weeks (range 4-20)
S3	22	Funct	All but one relieved	Mean 7 weeks (range 5-10)
S4	28	Qual & Funct	8 still had occasional discomfort	Mean 12 weeks
S5	78	Qual & Funct	all patients noted improvement	Mean 20 weeks (range 8-36)
S6	84	Qual & Funct	23 excellent, 7 good, 6 fair, 4 poor, 1 initially poor, but excellent after reoperation (scored as excellent)	Mean 25 weeks (range 6-96) (S6)
S7	NS	Qual & Funct	All dancers asymptomatic	Within weeks
S8	19	Qual & Funct	13/14 excellent	12 weeks
S9	40	Qual & Funct	Overall 74% good & excellent	11 weeks
S10	26	Quant (Kitaoka) postop only	Very good 13 (54%), good 5 (21%), satisfactory 5 (21%), poor 1 (4%)	NS
S11	36	Quant (AOFAS) & Funct	AOFAS van 85 naar 100	Excluded (S11)
S12	28	Quant (AOFAS) & Funct	AOFAS van 50 naar 97	10 weeks (range 7-13) (S12)
S13	46	Quant (RAND, FFI, VAS) & qual (patient satisfaction)	RAND same, FFI 126 -> 79, VAS 6 -> 1,2. At 2 years: good and excellent 96%	NS
S14	48	Quant (VAS pre- & postop), qual (anchor questions) & funct	VAS 7,7 -> 0,6; all improved plantarflexion ROM, all 17 FHL relief; 95% success, 100% recommend	RtD: 7,8 weeks (range 3-20), RtD (painfree): 17,7 weeks (range 6-52 weeks)
C1a	48	AOFAS, VAS, Qual., Funct	NS (C1) postop. AOFAS > 90; VAS: 1,25	Mean 16 weeks (range 8-24)
C1b	31	AOFAS, VAS, Qual., Funct	NS (C1) postop. AOFAS > 93; VAS: 0,8	Mean 7 weeks (range 6-8)
C2a	12	Functional	All patients were asymptomatic with regard to their ankle at the final follow-up visit (12 months)	Mean 14.9, range 9 to 20 weeks
C2b	12	Functional		Mean 9.8; range 9 to 20 weeks

Nr	FU	Overall Scoring	Overall results (see also table 3)	Overall Return to Dance or previous level of participation
	42	Qualitative 12	Excellent 68%, good: 21%, fair 7%, poor 4%	Average RtD (Hamilton S6 excluded)
	(range 12-84)	Functional 16		11,2 weeks (range: 4-36 wks) (n = 212 ankles)
	NS 2 case series	Quantitative 9 (since 2002)		Average RtD (all series, Hamilton included)
				13,4 weeks (range: 4-96 wks) (n = 253 ankles)
		Open: in 27 ankles of 27 dancers of two cohort studies (Guo 5, Ballal/Roche 22), all PAIS:		mean open: 15,1 weeks (n = 27)
		Endo: in 15 ankles of dancers of two cohort studies (Guo 2, Ballal/Roche 13), all PAIS:		mean endo: 9,4 weeks (n = 15)

... but the original data were not available anymore. That is why we decided to exclude his 1996 findings from the 'Average RtD (Hamilton (S6) excluded)'. In 'Average RtD (all series)' his 1996 findings are included to demonstrate the negative impact.
S11 Tey: unfortunately the return to dance data in this (endoscopic) case series of three dancers were unreliable, since the authors combined the data of sports and dance: "All the patients (including dance and sports!) were able to return to full performance without restriction at an average of 3 months'. Since this could not be traced, neither in the full text, nor in their table, these data were excluded.
S12 Vila: in full text 11 dancers, yet their Table 1 lists 6 dancers (4 F, 2 M, average age: 25). Following the data in their Table 1: the "recovery time for practice activity at the same level than before injury" for the 6 dancers is: 2,5 months, range: 1,8-3,2 months.
S14 Heyer: Average time to return to dance was 7.9 weeks, and time to pain-free dance was 17.7 weeks. We decided to use their 'Average Return to dance' (7,9 weeks) for our calculation.
C1 Guo: Postoperative score only, dance and sports mixed: the difference in postoperative score between open and endo was statistically not significant.
C2 Ballal: Groups not comparable: C2a Younger national ballet school dancers; C2b Older seasoned professional dancers. Open group considerably younger and different rehabilitation. 1 patient (7.7%) in endoscopic group and 3 (13.6%) in open group had concurrent lateral ligament reconstruction. 13 patients (59.1%) in open group had FHL tendon decompression compared with 2 patients (15.4%) in endoscopic group.

Table 7: Complications in 355 ankles (308 dancers) *

Open PL (n=47)	Open PM (n=184)	Open NS (n=99)	Endo (n=25)
6 (12,8%)	8 (4,%)	7 (7,1%)	1 (4%)
Open total (n = 330 ankles)			Endo (n = 25 ankles)
21 (6,4%)			1 (4%)
All complications in all operations (N = 355 ankles)			
22 (6,2%)			
More serious complications in all operations (n = 355)			
3 (0,8%) in all (n = 355)		3 (1%) in open only (n = 330)	

Procedure: open NS/PL/PM, open not specified (NS); open via posterolateral (PL) or open via posteromedial (PM) approach; * These numbers include four case series (52 operations in 44 dancers) in which we assumed there were no complications, however this was not specified.

Epidemiology and natural history of PAIS and/or FHL tendinopathy in dancers: We identified only one paper addressing the epidemiology and natural history of PAIS in dancers.[59] The authors observed 186 young trainee ballet dancers during one year, and found that 12/186 (6.5%) suffered from posterior ankle pain, of which 6/12 (50%) had an os trigonum. All 12 ballet dancers were treated non-operatively, and 9/12 (75%), including all six soft tissue impingement cases, had good results. In 3/12 (25%) cases after 1-4 months of unsuccessful conservative treatment, good results were obtained through surgical excision of the accessory ossicle.

Conservative treatment of PAIS and/or FHL tendinopathy in dancers: Six publications (three case reports, two case series, and one systematic review) described the results of conservative treatment of PAIS and/or FHL tendinopathy in 33 cases involving 28 dancers.[12;59;63;72;80;82] The quality and level of evidence of these publications was low, except for the systematic review.[80] See Table 8.

Table 8: Conservative treatment of PAIS and / or FHL in dancers (three case reports, two case series, one syst.review)

Table 8: Conservative treatment of PAIS and / or FHL in dancers (3 case reports, 2 case series, 1 syst.review)

Nr.	Year	Author	Type of study	Type of dance and level of participation	Dancers and/or ankles	Age	PAIS or FHL	Pathology	Successful cons.treatment	Return to Dance or previous level of participation
1	2006	Berglund	Case report	Female preprofessional modern dance-school student	1	17	1 FHL	FHL tendinopathy: 1	Yes	After 6 weeks symptomfree and participating in all dance activities
2	2008	Biggs	Case report	female ballet dancer	1	17	1 OT	Os trigonum: 1	No	Awaiting surgery
3	2010	Porter	Case report	female ballet dancer	1	17	1 FHL	FHL tendinopathy 1	No	Successful surgery
4	1998	Sammarco	Case series	female ballet dancers	13 dancers, 18 ankles	20	18 FHL	FHL 18	yes in 4 (22%) cases, no in 14 cases (78%)	14 cases surgery, 13 successful
5	2009	Albisetti	Case series	young trainee ballet dancers	12 dancers in an academic year of 186 dancers	14	12 PAIS	PAIS (soft tissue): 6, bony impingement (os trigonum): 6	yes in 9 (75%), no in 3 (25%) OT cases	9 'did well', 3 OT cases had successful surgery
6	2015	Ribbans	Syst.review	NA	NA	NA	NA	NA	NA	NA
			Average or total:	Ballet: 27, modern dance 1	28 dancers with 33 cases of PAIS or FHL	17	20 FHL, 13 PAIS (6 soft tissue, 7 OT)	See text	See text	

FHL, flexor hallucis longus tendinopathy; NA, not applicable; OT, os trigonum; PAIS, posterior ankle impingement syndrome.

Discussion

We are pleased to have found 27 publications describing the results of operative treatment of PAIS and FHL tendinopathy in dancers only, of which this is, to the best of our knowledge, the first systematic review. In these publications we found the results of 376 operations, with 89% good and excellent results, an average return to dance of 11.2 weeks, and 0.8% serious complications. Preliminary evidence shows that dancers operated on for FHL tendinopathy might recover significantly slower.

Unfortunately, the level of evidence of these studies, like that found in sports in general,[80] is confined to level four (non-comparative retrospective case series) and five (case reports and expert opinions). Two relatively recent (2014 and 2016) cohort studies retrospectively compare the open technique versus endoscopic surgical treatment for PAIS in dancers. Both studies are of low quality with regard to the comparative side and do not meet the criteria for level three. One is downgraded two levels and to be considered level five, given the low number of dancers, insufficient demographic data, missing description of the type of dance, level of participation, and return to dance, and mixed data of dance and sports.[78] The other retrospectively studied two case series of high-level ballet dancers, which also were briefly described in an expert opinion review in 2013.[79] The type of operation in this latter study's open group was not specified. Since the groups were not comparable, it is downgraded one level to level four.[77]

A limitation of our review is that it includes only the systematically searchable and hence for the medical profession readily accessible scientific literature, and has no additional records identified through other sources, like the reference lists of identified studies (except that this review included additional searches in the French medical literature, using Science Direct). We do not think this would alter the results, however, and feel it is of paramount importance to underline the scarcity and poor levels of evidence in the literature for these injuries in dancers, and have therefore dedicated most of the discussion to this.

Due to the low quality of the level of evidence of the available literature, the paucity of recent studies, and the low number of dancers treated endoscopically, the scientific evidence for the results of treatment of PAIS and/or FHL tendinopathy in dancers is currently imprecise and weak, and this limits translation to the individual patient. In particular, we identified the following limitations:

1 Type of dance and level of participation: These factors are poorly described and rarely specified, whereas they have an enormous impact on the levels of demands, required of the dancer, adding to the problem of evaluating outcome.

2 Inconsistent outcome reporting: A lack of consistent outcome reporting further complicates comparison. This makes it impossible to formulate firm conclusions and recommendations. Since 2002 quantitative pre- and post-operative outcome-scoring have become more common. Unfortunately, in our personal experience, the AOFAS is not sufficiently discriminative in dancers, because it has a "ceiling effect"; i.e., given the high demands of dance the AOFAS score may be 90/100 or more in spite of the fact that the dancer is unable to dance without limitations.[83;84] To date, in this search we found no evidence of use of a dance-specific outcome score like the Dance Functional Outcome System (DFOS),[85] in spite of the fact that this would be the preferred outcome measure. The DFOS focuses on dance-specific, functional movements, like relevé, that are unaddressed in other sports or generic questionnaires and provides a tool for investigating clinical efficacy in dance medicine.[86] We recommend that this tool be validated and used pre- and post-operatively at standardized intervals in combination with graded dance-specific rehabilitation.[87]
3 Low numbers of endoscopically treated dancers: Only 30 dancers (32 ankles) were treated endoscopically, compared to open: 294 dancers (344 ankles). The endo group forms only 9% of the total number of 324 operated dancers (376 ankles) in the literature to date, making conclusions regarding the preferred surgical procedure impossible.
4 Lack of clinical studies: As the research presented here makes abundantly clear, there is a paucity of clinical studies of PAIS and FHL tendinopathy, especially with regard to the epidemiology, natural history, and outcomes of conservative treatment in dancers.
5 Return to dance: This is a good functional outcome measure, provided the type of dance, level of participation, and timing of return to dance are described and differentiated, which rarely is the case. One of the flaws of all studies on PAIS and/or FHL tendinopathy in dancers is the poor, varying, or completely missing definition of return to dance. In ballet, for example, return to dance can have many different meanings, e.g., starting exercises with support (at the barre), resuming daily training in the group or company (class), or full performance (on pointe)[5] completely pain-free.[68] Furthermore, performances have varying levels of demand, the easiest being essentially pantomime, and the most demanding roles that include heavy dancing on pointe. Due to all these factors we found enormous differences in return to dance, varying from 4 to 36 weeks (not taking into account an "outlier" of 96 weeks).[5]

If "return to dance" is used as an outcome measure we recommend to differentiate, define, and preferably standardize the levels of return in a way that is universally applicable to all dance forms (not only ballet), and in accordance with the principles of graded and "preventive" rehabilitation.[87]

That is, the dancer is able to engage in the following dance activities:

1. *No impact:* fully assisted weight bearing ('barre'), including relevé and demi-plié, without turns or jumps;
2. *Low impact*: unassisted weight bearing, including explosive relevé and small jumps and turns;
3. *High impact:* big jumps and running
4. *Full dance performance*: including all requirements of the type of dance and level of participation.

Open operation or endoscopic: Given the differences in type of dance and level of participation, the variety in outcome measures of the found publications, and the low numbers of endoscopically treated dancers, it seems virtually impossible to compare the results of open surgery with endoscopic operations.

A small cohort study published in 2016 is the first to compare results of open surgery with the endoscopic technique specifically in dancers.[77] Unfortunately, the two groups are incomparable and their conclusion, that the endoscopic technique is superior to the open technique, is not justified: the larger proportion of FHL tendinopathy patients delays return to dance in their open group, as found in our review, whereas the larger proportion of professionals may make the surgical procedure more successful in their endo group. Besides, the larger proportion of concurrent lateral ligament reconstructions in their open group will have caused further delay in return to dance. From a return-to-dance point of view, it seems that the dancers in several open case series[20,30,38] return to dance faster than, or as fast as, after an endoscopic operation, suggesting that the open operation is at least equally attractive and perhaps even preferable (see Table 6). Looking at quantitative and qualitative results of both techniques, we found no evidence supporting superior long-term results of one technique over the other.

FHL tendinopathy: Dancers with isolated FHL tendinopathy (without PAIS), operated via an open posteromedial approach, returned to dance slower (16 weeks) than average (11 weeks: see Table 4).[69;72] However, the literature is not unequivocal on this subject, since dancers with a combination of PAIS and FHL tendinopathy, operated via the same open posteromedial approach, were the fastest (seven weeks) to return to (unspecified) dance.[68;76] But if "unspecified" is changed to "pain-free" return to dance the time doubles (14 weeks). These findings suggest that FHL tendinopathy with and without PAIS may be different injuries. So FHL injuries are challenging. In his proof of concept case report van Dijk describes one ballerina (two ankles) treated endoscopically for combined PAIS and FHL tendinopathy who had an excellent result and return to dance in eight weeks.[15] Hypothetically, dancers with FHL injuries may benefit most from the new endoscopic technique, given the good endoscopic

judgment of FHL pathology and the amount of dissection around the neurovascular bundle required in the open posteromedial approach. Release of the FHL tendon sheath can be done safely endoscopically,[88] provided the surgeon stays laterally of the tendon, "on the bone," but endoscopic FHL tendon repair is (as yet) impossible.

Age: The average age of all operated dancers in all case reports, case series, and in the two cohort studies (age specified in 175 dancers) was 21 years. There was no difference in age between the open (age specified in 150 dancers) and endoscopic (specified in 25 dancers) groups. PAIS and FHL tendinopathy are injuries that generally occur early in a dancer's career, and, if needed, operative treatment is a reasonably safe and successful procedure. This indicates that the fact that these ankle injuries are less common in older dancers may be explained by successful surgical treatment at a younger age, and not only by a "healthy worker effect". [1]

Complications: The general complication rates in sports, respectively 3.9% for open medial, 12.7% for open lateral, and 4.8% for arthro-endocopic surgery,[80] are comparable to the rates we calculated in dancers, respectively 2.8% for open posteromedial and 12.8% for open posterolateral, 4% for the endoscopic technique. In sports the complication rate of the endoscopic technique is 3.8% - 4.2%, with 1.8% requiring ongoing or operative intervention.[13,79] Surgical treatment of PAIS and FHL tendinopathy in dancers generates less than 1% serious complications.

Conservative treatment: We found no reliable results of conservative treatment of PAIS and FHL tendinopathy in dancers. In several publications that present the results of surgical treatment conservative treatment is described as well. Unfortunately these studies do not represent the results of conservative management, since "failed conservative treatment" is a prerequisite of the indication for surgery, and forms selection bias. Successful conservatively managed cases may be underreported.[12] Based on only the two case series we found it might be speculated that conservative treatment is successful in 75% of PAIS cases in dancers, being twice as successful in soft tissue impingement as in symptomatic os trigonum,[59] and in 22% of FHL tendinopathy in dancers.[72] Unfortunately, too little information has been made available to allow for any evidence-based recommendations to be made regarding the results of conservative treatment or the choice of non-surgical modalities.[80]

Natural history: The natural history of PAIS and FHL tendinopathy remains unknown. Based on one level 4 case series only, the prevalence of posterior ankle pain in young trainee ballet dancers is 6.5% (12/186 dancers).[59] Of course it is not realistic to extrapolate these data to dancers in general.

Dance and sports in general: Due to the fact that the systematic review by Ribbans et al. in 2015 assessed the efficacy of management of PAIS in sports in general, their findings are complementary to ours.[80] Since we studied dance specifically, and our search extended two and a half years longer, there was only 59% overlap between their reference list and ours. However, their references included two articles about dancers that were not found in our search because the various search terms we used concerning dance were mentioned in the full text only. In one article an 11-year old "dancing and swimming" girl is mentioned in a table: "surgical excision of a symptomatic os trigonum by medial approach bilaterally resulted in pain relief" and "resumption of sports activities at M3," without any further details.[89] Because of this unspecified remark we did not include it in our review. The second article was a review that mentioned a dancer in a case report, but this case report was already included in our study.[15;90] Ribbans et al. identified 827 surgeries for PAIS and FHL tendinopathy, of which 340 (41%) were open and 487 (59%) arthroscopic/endoscopic procedures. Overall, dance represented the most commonly reported recreational activity, with 62%. Dance especially dominated the open procedures (85%), whereas soccer (45%) was the most common activity treated endoscopically. Interestingly, in the earlier literature on open operations the type of sport was specified in 298 (88%) of the entries, of which 252 (85%) were dancers, which constituted 74% of the total procedures. In the more recent literature on endoscopic surgical treatment the type of sport was specified in 147 (30%) cases, of which 26 (18%) were dancers, which accounted for only 5% of the total number of cases. In our opinion this is due to the fact that in the endoscopic publications the emphasis was more on the new technique and its implications than on the demands and type of activity of the patients, and secondly that many fewer dancers were treated in the endoscopic group than in the open group.

The overall analysis of Ribbans et al. revealed osseous involvement of various forms in 81% of cases, and FHL tendinopathy involvement in 35% of cases. The incidence of FHL tendinopathy involvement was more often reported in dance (52%) than in soccer (20%), indicating an important difference between the two activities.

Conclusions

1. The quality and level of evidence in the clinical studies of PAIS and/or FHL tendinopathy in dancers is confined to levels four and five;
2. Operative treatment of PAIS and/or FHL tendinopathy in dancers is unequivocally successful (89% good and excellent results), has an average return to dance in 11 weeks, and has less than 1% serious complications, regardless of the surgical technique used.
3. Operative treatment of isolated FHL tendinopathy in dancers seems to have the longest return to dance time: 16 weeks.

4. We found similar results in open and endoscopic operations, both in terms of return to dance times and end result.
5. There is a lack of studies on the epidemiology, natural history, and outcomes of conservative treatment for these conditions in dancers.
6. Preliminary results in only six studies of low quality suggest a 75% success of conservative treatment (including injections) in PAIS generally, being most successful in soft tissue impingement, 50% successful in case of asymptomatic os trigonum,[59] and least successful in case of FHL tendinopathy.[72]
7. The average age of patients operated for PAIS and/or FHL tendinopathy is 21 years, so the operation tends to occur early in a dancer's career.

Recommendations

If conservative treatment fails, dancers with PAIS and/or FHL tendinopathy may confidently undertake surgical management, given the good outcome and low risk.

However, since isolated PAIS, PAIS combined with FHL tendinopathy, and isolated FHL injuries seem to be different pathological entities, more research is needed to determine in which cases early operative management should be considered or avoided, taking into account demography, dance type, and level of participation. The same applies to defining the place of endoscopic surgery in dancers, and to being able better to predict which pathology is likely to produce worse outcomes or delay in return to dance.

In general large, preferably prospective, clinical (comparative) cohort studies are recommended, with a good description of the demography, type of dance, and level of participation involved, as well as the use of a validated functional, dance-specific outcome score, and a preferably standardized definition and differentiation of the levels of "return to dance," both pre- and post-treatment.

A prospective, randomized, controlled design should be used to compare different conservative and operative treatment options.

Given the lack of publications on the outcomes of conservative treatment, any clinical studies on this subject are more than welcome, to be able to predict in which cases conservative measures are most likely to be beneficial, and which treatment modalities will be most effective.

References

1 Rietveld B. Dance injuries in the older dancer: comparison with younger dancers. Journal of Dance Medicine & Science. 2000;4(1):16-19.

2 Caine D, Goodwin BJ, Caine CG, Bergeron G. Epidemiological Review of Injury in Pre-Professional Ballet Dancers. J Dance Med Sci. 2015;19(4):140-148.

3 Ramkumar PN, Farber J, Arnouk J, Varner KE, McCulloch PC. Injuries in a Professional Ballet Dance Company: A 10-year Retrospective Study. J Dance Med Sci. 2016;20(1): 30-37.

4 van Dijk CN. Anterior and posterior ankle impingement. [Review] [48 refs]. Foot & Ankle Clinics. 2006;11(3):663-683.

5 Hamilton WG, Geppert MJ, Thompson FM. Pain in the posterior aspect of the ankle in dancers. Differential diagnosis and operative treatment. J Bone Joint Surg Am. 1996;78(10):1491-1500.

6 Rietveld ABM, Haitjema S. Posterior ankle impingement syndrome and m. flexor hallucis longus tendinitis in dancers: results of open surgery. In press J Dance Med Sci.

7 Hamilton WG. Dancer's tendinitis of the FHL tendon. In: Second Annual Meeting of the American Orthopaedic Society for Sports Medicine, Durango, Colorado, July. 1976, pp. 11-14.

8 Hamilton WG. Tendonitis about the ankle joint in classical ballet dancers. American Journal of Sports Medicine. 1977;5(2):84-88.

9 Hamilton WG. Stenosing tenosynovitis of the flexor hallucis longus tendon and posterior impingement upon the os trigonum in ballet dancers. Foot Ankle. 1982;3(2):74-80.

10 Thomasen E. Diseases and Injuries of Ballet Dancers. Universitetsforlaget i Århus, 1982.

11 Howse AJ. Dance Technique and Injury Prevention. A & C Black, London, 2000.

12 Berglund CL, Philipps LE, Ojofeitimi S. Flexor hallucis longus tendinitis among dancers. Orthopaedic Physical Therapy Practice. 2006;18(3):26-31.

13 Nowacki RM, Air ME, Rietveld AB. Use and effectiveness of orthotics in hyperpronated dancers. J Dance Med Sci. 2013;17(1):3-10.

14 Hamilton WG. Posterior ankle pain in dancers. [Review] [32 refs]. Clinics in Sports Medicine. 2008;27(2):263-277.

15 van Dijk CN, Scholten PE, Krips R. A 2-portal endoscopic approach for diagnosis and treatment of posterior ankle pathology. Arthroscopy. 2000;16(8):871-876.

16 van Dijk CN. Hindfoot endoscopy. Foot Ankle Clin. 2006;11(2):391-414.

17 van Dijk CN, van Bergen CJ. Advancements in ankle arthroscopy. J Am Acad Orthop Surg. 2008;16(11):635-646.
18 van Dijk CN, de Leeuw PA, Scholten PE. Hindfoot endoscopy for posterior ankle impingement. Surgical technique. J Bone Joint Surg Am. 2009;91 Suppl 2:287-298.
19 Howse AJ. Orthopaedists aid ballet. Clin Orthop Relat Res. 1972;89:52-63.
20 Bauman PA, Gallagher SP, Hamilton WG. Common foot, ankle, and knee problems in professional dancers: Orthopaedic and physical therapy evaluation and care. Orthopaedic Physical Therapy Clinics of North America. 1996;5(4):497-513.
21 Brown TD, Micheli LJ. Foot and ankle injuries in dance. [Review] [34 refs]. American Journal of Orthopedics (Chatham, Nj). 2004;33(6):303-309.
22 Chao W. Os trigonum. Foot Ankle Clin. 2004;9(4):787-96.
23 Denton J. Overuse foot and ankle injuries in ballet. Clinics in Podiatric Medicine and Surgery. 1997;14(3):525-532.
24 Fond D. Flexor hallucis longus tendinitis-a case of mistaken identity and posterior impingement syndrome in dancers: evaluation and management. J Orthop Sports Phys Ther. 1984;5(4):204-206.
25 Funasaki H, Hayashi H, Sakamoto K, Tsuruga R, Marumo K. Arthroscopic Release of Flexor Hallucis Longus Tendon Sheath in Female Ballet Dancers: Dynamic Pathology, Surgical Technique, and Return to Dancing Performance. Arthroscopy Techniques. 2015;4(6):769-774.
26 Giannini S, Buda R, Mosca M, Parma A, Di Caprio F. Posterior Ankle Impingement. Foot & Ankle International. 2013;34(3):459-465.
27 Hamilton WG. Foot and ankle injuries in dancers. [Review] [27 refs]. Clinics in Sports Medicine. 1988;7(1):143-173.
28 Hamilton WG. Differential diagnosis and treatment of posterior ankle pain in dancers and equinus athletes. J Back Musculoskelet Rehabil. 1995;5(3):201-207.
29 Hardaker WT, Jr., Margello S, Goldner JL. Foot and ankle injuries in theatrical dancers. Foot Ankle. 1985;6(2):59-69.
30 Howse AJ. Posterior block of the ankle joint in dancers. Foot Ankle. 1982;3(2):81-84.
31 Kadel N, Micheli LJ, Solomon R. Os trigonum impingement syndrome in dancers. Journal of Dance Medicine & Science. 2000;4(3):99-102.
32 Kadel N. Foot and ankle problems in dancers. [Review]. Physical Medicine & Rehabilitation Clinics of North America. 2014;25(4):829-844.

33 Kadel NJ. Excision of os trigonum. Operative Techniques in Orthopaedics. 2004;14(1): 1-5.

34 Kadel NJ. Foot and ankle injuries in dance. Phys Med Rehabil Clin N Am. 2006;17(4): 813-26.

35 Kennedy JG, Hodgkins CW, Colombier JA, Guyette S, Hamilton WG. Foot and ankle injuries in dancers. International Sportmed Journal. 2007;8(3):141-165.

36 Khan K, Brown J, Way S et al. Overuse injuries in classical ballet. [Review] [82 refs]. Sports Medicine. 1995;19(5):341-357.

37 Kleiger B. The posterior tibiotalar impingement syndrome in dancers. Bull Hosp Jt Dis Orthop Inst. 1987;47(2):203-210.

38 Luk P, Thordarson D, Charlton T. Evaluation and management of posterior ankle pain in dancers. J Dance Med Sci. 2013;17(2):79-83.

39 Macintyre J, Joy E. Foot and ankle injuries in dance. Clinics in Sports Medicine. 2000;19(2):351.

40 Maquirriain J. Posterior ankle impingement syndrome. [Review] [18 refs]. Journal of the American Academy of Orthopaedic Surgeons. 2005;13(6):365-371.

41 Motta-Valencia K. Dance-Related Injury. Physical Medicine and Rehabilitation Clinics of North America. 2006;17(3):697-723.

42 Nault ML, Kocher MS, Micheli LJ. Os trigonum syndrome. [Review]. Journal of the American Academy of Orthopaedic Surgeons. 2014;22(9):545-553.

43 Quirk R. Common foot and ankle injuries in dance. Orthop Clin North Am. 1994;25(1):123-133.

44 Rietveld ABM. Dancers' and musicians' injuries. [Review]. Clinical Rheumatology. 2013;32(4):425-434.

45 Schon LC, Weinfeld SB. Lower extremity musculoskeletal problems in dancers. Current Opinion in Rheumatology. 1996;8(2):130-142.

46 Siev-Ner I. Common overuse injuries of the foot and ankle in dancers. Journal of Dance Medicine & Science. 2000;4(2):49-53.

47 Teitz CC. Diagnosing and managing common dance injuries. Journal of Musculoskeletal Medicine. 1996;13(6):46-57.

48 Trevino S, Baumhauer JF. Tendon injuries of the foot and ankle. Clinics in Sports Medicine. 1992;11(4):727-739.

49 Werber B. Dance Medicine of the Foot and Ankle: A Review. Clinics in Podiatric Medicine and Surgery. 2011;28(1):137-154.

50 Wybier M H-LCSJ. Pathologie du carrefour postérieur de la cheville et danse classique. In: Haddad A, ed.: Actualitées rhumatologiques du sportif. 2010, pp. 89-100.
51 Wykman A, Oxelbeck U. Pain symptoms and injuries among ballet dancers--diagnosis and treatment. [Swedish]. Lakartidningen. 1991;88(13):1207-1210.
52 Sammarco GJ, Miller EH. Partial rupture of the flexor hallucis longus tendon in classical ballet dancers: two case reports. J Bone Joint Surg Am. 1979;61(1):149-150.
53 Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ. 2009;339:b2535.
54 Hussain N, Yankanah R, Wright JG. The validity of level of evidence ratings of articles submitted to JBJS. J Bone Joint Surg Am. 2015;97(2).
55 Wright JG, Swiontkowski MF, Heckman JD. Introducing levels of evidence to the journal. J Bone Joint Surg Am. 2003;85-A(1):1-3.
56 Atkins D, Best D, Briss PA et al. Grading quality of evidence and strength of recommendations. BMJ. 2004;328(7454):1490.
57 Russell JA, Kruse DW, Koutedakis Y, McEwan IM, Wyon MA. Pathoanatomy of posterior ankle impingement in ballet dancers. Clin Anat. 2010;23(6):613-621.
58 Ahn JH, Kim YC, Kim HY. Arthroscopic Versus Posterior Endoscopic Excision of a Symptomatic Os Trigonum A Retrospective Cohort Study. American Journal of Sports Medicine. 2013;41(5):1082-1089.
59 Albisetti W, Ometti M, Pascale V, De BO. Clinical evaluation and treatment of posterior impingement in dancers. Am J Phys Med Rehabil. 2009;88(5):349-354.
60 Almazan DA, Gonzalez TM, Bravo MC, Valdez K, Luis SS, Ponce de Leon JC. [Endoscopic technique with two posterior portals for treatment of the posterior pathology of the ankle. Technique description and case report]. Acta Ortop Mex. 2008;22(5):321-324.
61 Garth J. Flexor hallucis tendinitis in a ballet dancer. A case report. Journal of Bone and Joint Surgery - Series A. 1981;63(9):1489.
62 Lereim P. Trigger toe in classical-ballet dancers. Arch Orthop Trauma Surg. 1985;104(5):325-326.
63 Porter EB, Dubois MS, Raasch WG. A 17-year-old ballet dancer with medial ankle pain. Curr Sports Med Rep. 2010;9(5):290-291.
64 Quirk R. Talar compression syndrome in dancers. Foot and Ankle. 1982;3(2):65-68.
65 Brodsky AE, Khalil MA. Talar compression syndrome. Am J Sports Med. 1986;14(6):472-476.

66 Coetzee JC, Seybold JD, Moser BR, Stone RM. Management of Posterior Impingement in the Ankle in Athletes and Dancers. Foot Ankle Int. 2015;36(8):988-994.
67 Heim M, Siev-Ner I, Huszar M, Engelberg S, Rottenberg F, Azaria M. Retrotalar fat impingement: an old concept, a new idea. Foot. 1997;7(2):97-100.
68 Heyer JH, Rose DJ. Os Trigonum Excision in Dancers via an Open Posteromedial Approach. Foot Ankle Int. 2016.
69 Kolettis GJ, Micheli LJ, Klein JD. Release of the flexor hallucis longus tendon in ballet dancers. J Bone Joint Surg Am. 1996;78(9):1386-1390.
70 Labs K, Leutloff D, Perka C. Posterior ankle impingement syndrome in dancers - A short-term follow-up after operative treatment. Foot and Ankle Surgery. 2002;8(1):33-39.
71 Marotta JJ, Micheli LJ. Os trigonum impingement in dancers. Am J Sports Med. 1992;20(5):533-536.
72 Sammarco GJ, Cooper PS. Flexor hallucis longus tendon injury in dancers and nondancers. Foot Ankle Int. 1998;19(6):356-362.
73 Spicer DDM, Howse AJG. Posterior block of the ankle: The results of surgical treatment in dancers. Foot and Ankle Surgery. 1999;5(3):187-190.
74 Tey M, Monllau JC, Centenera JM, Pelfort X. Benefits of arthroscopic tuberculoplasty in posterior ankle impingement syndrome. Knee Surg Sports Traumatol Arthrosc. 2007;15(10):1235-1239.
75 Vila J, Vega J, Mellado M, Ramazzini R, Golano P. Hindfoot endoscopy for the treatment of posterior ankle impingement syndrome: A safe and reproducible technique. Foot and Ankle Surgery. 2014;20(3):174-179.
76 Wredmark T, Carlstedt CA, Bauer H, Saartok T. Os trigonum syndrome: a clinical entity in ballet dancers. Foot Ankle. 1991;11(6):404-406.
77 Ballal MS, Roche A, Brodrick A, Williams RL, Calder JDF. Posterior Endoscopic Excision of Os Trigonum in Professional National Ballet Dancers. Journal of Foot & Ankle Surgery. 2016;55(5):927-930.
78 Guo QW, Hu YL, Jiao C, Fang Y, Tian DX. Open Versus Endoscopic Excision of a Symptomatic Os Trigonum: A Comparative Study of 41 Cases. Arthroscopy-the Journal of Arthroscopic and Related Surgery. 2010;26(3):384-390.
79 Roche AJ, Calder JD, Lloyd WR. Posterior ankle impingement in dancers and athletes. [Review]. Foot & Ankle Clinics. 2013;18(2):301-318.
80 Ribbans WJ, Ribbans HA, Cruickshank JA, Wood EV. The management of posterior ankle impingement syndrome in sport: a review. Foot Ankle Surg. 2015;21(1):1-10.

81 Brodsky AE, Khalil MA. Talar compression syndrome. Foot Ankle. 1987;7(6):338-344.
82 Biggs AL. Posterior ankle impingement in a ballet dancer: a case of Os trigonum syndrome. Clinical Journal of Sport Medicine. 2008;18(2):217.
83 Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int. 1994;15(7):349-353.
84 Kitaoka HB, Patzer GL. Analysis of clinical grading scales for the foot and ankle. Foot Ankle Int. 1997;18(7):443-446.
85 Bronner S, Novella T, Becica L. Management of a delayed-union sesamoid fracture in a dancer. J Orthop Sports Phys Ther. 2007;37(9):529-540.
86 Bronner S., Smith T.R., Brown K., Urbano I. Bronner S.; Smith T.R.; Brown K.; Urbano I. Reliability and validity of a dance outcomes instrument. In: APTA Combined Sections Meeting 2016, Annaheim, CA, USA. 2016
87 Air M, Rietveld ABM. Dance-specific, graded rehabilitation: advice, principles and schedule for the general practitioner. Med Probl Perform Art. 2008;23(3):114-119.
88 Donnenwerth MP, Roukis TS. The Incidence of Complications After Posterior Hindfoot Endoscopy. Arthroscopy-the Journal of Arthroscopic and Related Surgery. 2013;29(12):2049-2054.
89 de Landevoisin ES, Jacopin S, Glard Y, Launay F, Jouve JL, Bollini G. Surgical treatment of the symptomatic os trigonum in children. Orthopaedics & Traumatology-Surgery & Research. 2009;95(2):159-163.
90 Smyth NA, Zwiers R, Wiegerinck JI et al. Posterior hindfoot arthroscopy: a review. Am J Sports Med. 2014;42(1):225-234.