Surgical Outcomes of Os Trigonum Syndrome in Dancers

A Case Series

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Background: Management of ankle pain in dancers can be challenging because of the repetitive stress and complex demands placed on this region. Despite the prevalence of ankle injuries in this population, literature on surgical outcomes and return to dance is limited.

Purpose: To retrospectively evaluate the efficacy and functional outcomes after surgical excision of a symptomatic os trigonum in dancers.

Study Design: Case series; Level of evidence, 4.

Methods: Between June 2006 and June 2016, a total of 44 dancers underwent surgical excision of a symptomatic os trigonum at a single institution and by a single surgeon. All patients presented with symptoms of posterior ankle impingement syndrome and subsequently failed nonsurgical treatment. Clinical analysis was conducted using various pre- and postoperative patient-reported outcome questionnaires, including the Veterans RAND 12-Item Health Survey (VR-12), Foot Function Index–Revised (FFI-R), and visual analog scale (VAS) for pain, as well as subjective patient satisfaction.

Results: A total of 44 patients (54 ankles; mean age, 18.2 years) were retrospectively evaluated at a mean follow-up of 33.4 months. The VR-12 Physical Health score improved from a mean score of 37.8 ± 11.9 to 51.2 ± 10.5 ($P < .001$). The cumulative FFI-R score improved from 46.45 ± 13.8 to 31.2 ± 9.7 ($P = .044$), with the subcategory of "activity limitation" representing the highest-scoring FFI-R subcategory at 65.28 ± 13.4 preoperatively and improving to 34.47 ± 12.4 at follow-up ($P < .001$). The mean VAS score for subjective pain improved significantly from 5.39 ± 2.84 to 1.73 ± 2.10 ($P < .00044$).

Conclusion: Overall, the findings of the present study demonstrate that dancers of varying style and level improved significantly according to various clinical measures. Patients included in this study reported that they returned to their previous level of dance upon completion of physical therapy and maintained thriving postoperative careers, which for several meant dancing at the professional level.

Keywords: posterior ankle impingement; os trigonum; dancers; sports; foot and ankle injury

Classical dance forms have a rich history as a performing art, drawing audiences to the poise and athleticism of the dancers as they maintain impressive postural and dynamic control while moving across the stage. Dance continues to be a popular sport and recreational activity that places extreme physical demands on the body, particularly on the foot and ankle. Various reviews[8,16,28,29] have highlighted the unique musculoskeletal injuries caused by the training and performance to which the dancers are predisposed. Specifically, lower extremity injuries are the most common type of injury in dancers, with studies reporting up to 57% of injury distribution related to the foot and ankle.[8]

Most classical-based styles of dance, such as ballet, jazz, modern, and contemporary, include *relevé* (meaning "raised") in a *demi-pointe* (on the ball of the foot) or fully *en point* (on the tips of the toes), in which dancers are required to sustain plantarflexion at a high degree and frequency. For young performers, transitioning to dance en pointe represents a significant step toward dancing on an elite level. A young dancer is assessed carefully for pointe readiness with regard to technique, physical development, flexibility in the hip and ankle, and postural strength and stability.[17,27] Poorly developed or weakly trained hip abductors can lead to postural sway and compensation by ankle inversion. Additionally, if relevé is

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performed inadequately, the ankle will compensate with neutral foot alignment and expose the lateral ankle ligaments to increased stress and potential for sprain injuries.[1] Even with proper mechanics, dance en pointe can apply comprehensive forces of up to 12 times the body weight on the dancer's foot and ankle.[9] In excess, these compressive forces in maximum plantarflexion can result in posterolateral ankle pain and restriction, known as posterior ankle impingement syndrome (PAIS).[11,21,25,26]

PAIS can be caused by both osseous and soft tissue structures. One such osseous cause is the os trigonum, an accessory ossicle to the talus that is normally present in 13% of the population[31] and is usually asymptomatic. The os trigonum exists as the result of a persistent, separate lateral ossification center on the posterior aspect of the talus that normally rapidly fuses with the medial and lateral tubercles during preadolescence.[32] Acquired os trigonum syndrome is caused by an injury that prevents fusion and can subsequently become symptomatic when it impinges on the surrounding soft tissue structures wedged between the tibia, talus, and calcaneus in plantarflexion.[11,21,26] It has been reported that repetitive plantarflexion trauma in a young dancer's training prevents proper closure of this trigonal ossification center[19,23] and is accompanied by pathology of the flexor hallucis longus (FHL) tendon.[13] Therefore, it is easy to understand that transitioning to relevé training during preadolescence can cause PAIS in a young dancer.

Nonoperative treatment is initiated in the early stage of PAIS. However, because of the osseous etiology of acquired os trigonum syndrome, surgical intervention is often required because of recalcitrant posterior ankle pain. The traditional open surgical excision of the os trigonum through a posteromedial or posterolateral approach has good results and relatively few complications and provides the advantage of performing FHL tenolysis versus an arthroscopic approach.[7,15] Additionally, a hindfoot endoscopic technique[33] has shown comparable clinical outcomes regarding pain, function, and satisfaction and may shorten the recovery time and result in lower complication rates.[4,12] However, it limits access to concomitant FHL pathology. Despite theoretical advantages of greater access to the posterior ankle and subtalar joint with arthroscopy, imaging has ruled out addressing any posterior articular issues. Postoperatively, dancers typically return to dance within 2-3 months after a rigorous and structured course of physical rehabilitation therapy.[7,15,18,20]

TABLE 1
Participating Patient Characteristics (N = 44)

Sex, n (%)	
Male	4 (9.1)
Female	40 (90.9)
Age at surgery, y, mean ± SD (range)	18.2 ± 6.9 (9.9-50.2)
Ankle, n (%)	
Left	21 (47.7)
Right	13 (29.5)
Both	10 (22.7)
Body mass index at surgery, kg/m^2, mean ± SD (range)	22.5 ± 4.1 (15.0-35.4)
Prior ankle surgery, n (%)	0 (0.0)
Activity level, n (%)	
Multiple disciplines of dance	29 (65.9)
Ballet	25 (56.8)
Professional	5 (11.4)
College program	4 (9.1)

Here, we demonstrate a retrospective case series of 44 dancers who were evaluated after undergoing surgical excision of a symptomatic os trigonum that resulted in secondary PAIS.

METHODS

Patient Selection and Case Summary

Approval was obtained by a local institutional review board, and a retrospective chart review included surgeries between June 2006 and June 2016. The 44 patients in this study indicated their primary sport was dance and obtained a diagnosis of a symptomatic os trigonum. Table 1 summarizes the patient characteristics included in this study. Dancers were predominantly female (90.9%), and a majority (65.9%) had dance activities across multiple disciplines. Most of the dancers indicated that they were in a type of ballet (56.8%), including at the professional level (11.4%). Of the 44 patients, most underwent unilateral os trigonum surgery (21 left, 13 right ankles) compared with bilateral (10 patients). Of the bilateral cases, only 3 occurred on the same surgical date. None reported prior surgery to their ankle, with the exception of those returning at a later date for their contralateral os trigonum.

On examination, the dancers described pain and tenderness in the posterolateral aspect of the ankle in relevé

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Ethical approval for this study was obtained from the University of Minnesota Institutional Review Board (ID No. 1405M50406).

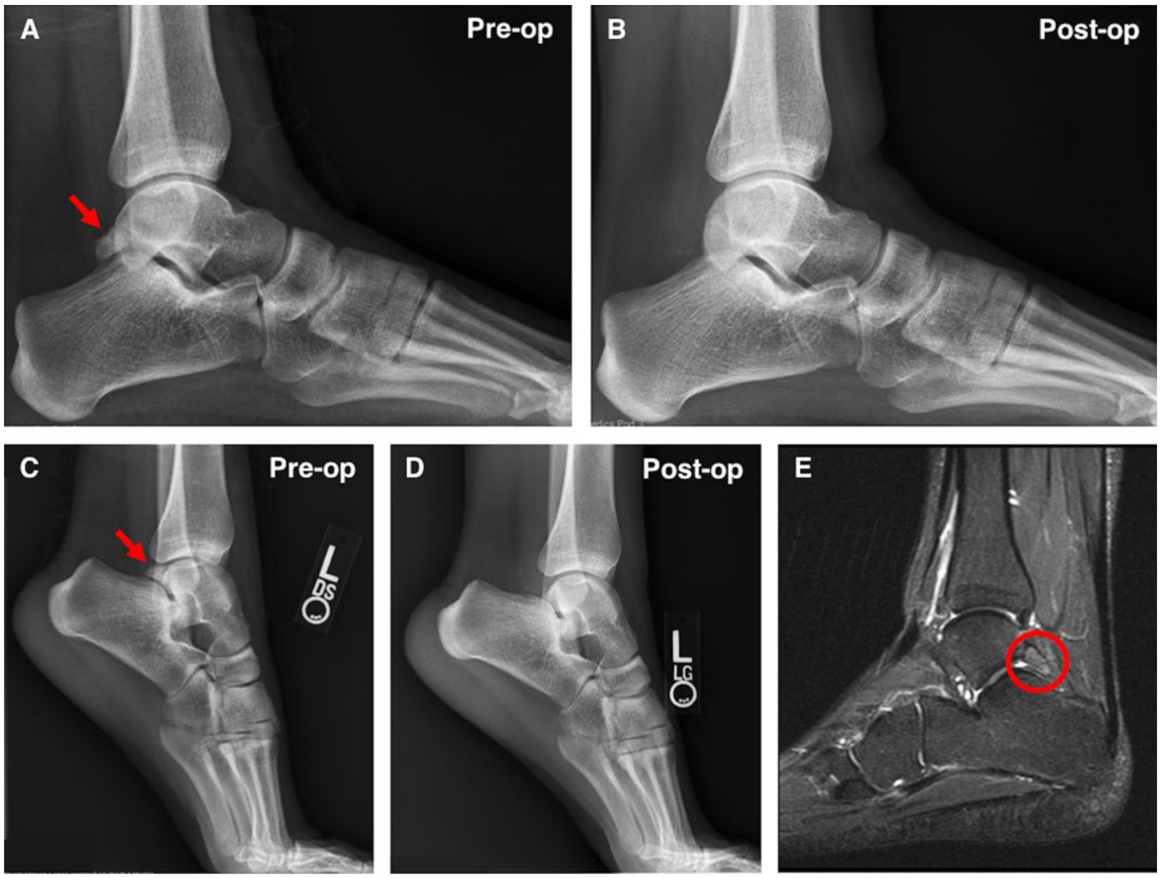

Figure 1. Imaging characteristics of a symptomatic os trigonum. Imaging was obtained upon positive clinical indication of posterior ankle impingement, represented here in a single dancer included in the study. (A) Lateral weightbearing radiographs obtained preoperatively revealed an os trigonum posterior to the talus (red arrow) compared with that obtained from (B) surgical excision at 6-month follow-up. Additionally, (C) demi-pointe lateral radiograph of the same dancer showed restriction of normal plantarflexion compared with that obtained (D) after follow-up. (E) Magnetic resonance imaging was used to further evaluate the size of the ossicle (red circle), as well as focal edema in the hindfoot of soft tissue structures being impinged.

(plantarflexion). Obvious restricted range of motion both actively and passively, with the knee flexed to 90°, was noted in plantarflexion. Pain was exacerbated with axial loading and often with dorsiflexion of the great toe, as the FHL tendon pushes against the ossicle over its groove along the talus. Dancers meeting clinical criteria for PAIS were radiograph imaged in standard weightbearing anteroposterior, lateral, and plantarflexion views (Figure 1). Magnetic resonance imaging was also performed as recommended to further evaluate the size of the os trigonum, as well as the areas of edema and soft tissue structures in the hindfoot that were being impinged.[21,23] This allows for further differentiation from other etiologies of posterior ankle pain and adds to clinical consideration of the severity of symptoms.

Nonsurgical interventions are the first-line treatment for patients presenting with PAIS, but surgical excision is the only definitive treatment to prevent recurrence of symptoms. In addition to initiating a physical therapy program, patients with symptoms are advised to immobilize the ankle in a controlled ankle motion walking boot for 6 weeks and/or treat with nonsteroidal anti-inflammatory drugs, as needed. Patients with recalcitrant pain may seek symptom relief with steroid injection, but inevitably, surgical intervention is necessary to remove the stressed ossicle.

Overview of Operative Procedure

All patients in this study underwent open excision by a single surgeon (J.C.C.) and predominantly through a posteromedial approach (Figure 2). Initially for 16 patients in the study, a posterolateral approach was taken, as it was the shortest distance to the os trigonum. The subsequent 38 cases were performed from a posteromedial approach, as it allowed a much better access to the FHL, and once retracted, easy access to the os trigonum.

A medial incision was made in the interval between the flexor digitorum longus and the neurovascular bundle. The bundle was carefully retracted posteriorly, and blunt dissection was used to identify the FHL. A tenosynovectomy was done to release the tendon and remove any adherent tissue. The FHL was then retracted posteriorly to expose

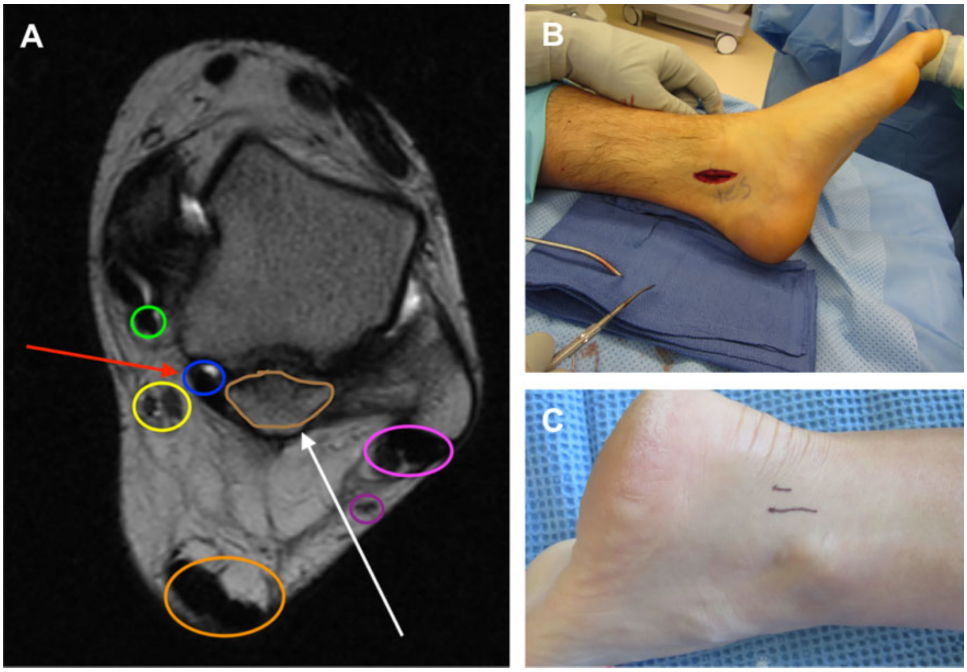

Figure 2. Posterior ankle anatomy and operative considerations. This gives a schematic visualization of the medial and lateral approaches to the ankle. (A) The posteromedial surgical approach (red arrow) is between the flexor digitorum longus (green circle) and the neurovascular bundle (yellow circle). The next structure that is exposed is the flexor hallucis longus (blue circle) and the os trigonum (brown circle). In contrast, the posterolateral approach (white arrow) is between the peroneal tendons (pink circle) and the Achilles tendon (orange circle). The sural nerve (purple circle) should be identified and protected. (B) Medial approach is done with the patient supine and the leg in a figure-of-4 position. (C) Lateral approach is done with the patient prone, and the incision for open excision is comparable with that of an arthroscopic approach.

the os trigonum directly lateral to the groove for the FHL on the talus. An arthroscopic shaver was used in an open fashion to remove and debride any excess scar tissue. A small osteotome or freer was used to mobilize the os trigonum before removal. For the posterolateral approach, a lateral incision was made halfway between the Achilles and peroneal tendons. Great care was taken to protect the sural nerve. Blunt and sharp dissection were then employed to enter the posterolateral aspect of the ankle joint, exposing the os trigonum to removal. After surgery, a specific postoperative rehabilitation protocol was followed for 12 weeks (Table 2).

Outcome Measures and Statistical Analysis

Patient-reported outcomes (PROs) were evaluated preoperatively and postoperatively with the Veterans RAND 12-Item Health Survey (VR-12) Mental Health and Physical Health summary scores, Foot Function Index–Revised (FFI-R), and visual analog scale (VAS) pain scoring. The FFI-R consists of 4 subscales (pain and stiffness, difficulty, activity limitation, and social issues) and 68 items and is an assessment of total foot function.[6] Statistical significance between preoperative and postoperative mean scores for each PRO was calculated using the Welch t test. Postoperative scores included values at the latest follow-up

TABLE 2
Postoperative Physical Rehabilitation Timeline and Goals[a]

Phase	Weeks	Therapy Goals
1	0-2	Week 1: CAM boot and partial weightbearing with crutches Week 2: Weightbearing as tolerated and initiation of physical therapy
2	2-6	Exercises 2-4 weeks: Gait training, AROM PF without maximal contraction, AROM DF to neutral, gentle FHL stretching, intrinsic activation in sitting (short foot/dome exercises), toe yoga, balance progressions, proximal neuromuscular re-education, and strengthening; weightbearing as tolerated Exercises 4-6 weeks: Dynamic balance progression, band-resisted plantarflexion, dance-specific movement progressions
3	6-12	Exercises 6-8 weeks: Cardio/fitness (bicycling, elliptical), calf strengthening; modified return to dance class at 6 weeks Exercises 9-12 weeks: Progressive weightbearing plyometrics, initiation of sports-specific training, passing of functional tests for sport

[a]AROM, active range of motion; CAM, controlled ankle motion; DF, dorsiflexion; FHL, flexor hallucis longus; PF, plantarflexion.

TABLE 3
Preoperative and Postoperative Change in Outcome Scores at Last Follow-Up[a]

Measure	Preoperative	Postoperative	P^b
FFI-R			
Pain	42.86 ± 16.9	28.73 ± 14.1	.10269
Stiffness	45.24 ± 17.7	32.79 ± 12.0	.15609
Difficulty	52.27 ± 18.0	34.30 ± 11.7	.05930
Activity limitation	65.28 ± 13.4	34.47 ± 12.4	.00095
Social issues	31.94 ± 6.8	25.95 ± 4.3	.08594
Cumulative	46.45 ± 13.8	31.18 ± 9.7	.04377
VR-12			
Physical	37.77 ± 11.86	51.17 ± 10.53	.00004
Mental	55.37 ± 10.95	53.87 ± 9.04	.68816
VAS	5.39 ± 2.84	1.73 ± 2.10	.00044

[a]Data are presented as mean ± SD. FFI-R, Foot Function Index–Revised Short Form; VAS, visual analog scale; VR-12, Veterans RAND 12-Item Health Survey.

[b]Welch unequal variances *t* test for difference in change from preoperative scores between groups.

appointment for each patient. Thus, final scores represented a distinct data point along a longitudinal range of follow-up time rather than a discrete point for all patients. Analysis was performed using JMP software (SAS Institute), and significance was determined as $P < .001$.

RESULTS

For the 44 patients (54 ankles) included in this study, the latest follow-up was at a mean of 33.4 months (range, 12.0-102.6 months). The pre- and postoperative outcome scores are shown in Table 3. The VR-12 Physical Health score improved from a mean preoperative score of 37.77 ± 11.86 (range, 16-56) to 51.17 ± 10.53 (range, 29-67) at the most recent follow-up, which was significant at $P < .001$. VR-12 Mental Health score remained roughly the same preoperatively and postoperatively, with mean scores of 55.37 to 53.87, respectively. FFI-R cumulative score improved (reduced) from 46.45 ± 13.8 (range, 29-60) to 31.18 ± 9.7 (range, 23-54) ($P = .04$). Specifically, the preoperative scores for the FFI-R subcategories of "activity" (65.28) and "difficulty" (52.27) represented the highest values within that measure and therefore can said to be the greatest problems identified on the questionnaire for dancers based on symptoms. Both of these values were reduced by 34% at the last follow-up, with activity limitation representing the greatest significance ($P < .001$).

The mean VAS score improved significantly from 5.39 ± 2.84 to 1.73 ± 2.10, representing a 68% improvement from preoperative baseline for subjective pain assessment ($P < .001$). Three patients reported discomfort from scar tissue, which resolved through therapy, 2 patients reported sural nerve injuries that eventually healed, and 1 patient experienced mild peroneus brevis tendinitis as a result of compensatory pain on follow-up, but it was unclear if this was a direct result of surgery. Overall, patients rated their satisfaction with results as 83% at the time of last follow-up. All study patients reported that they had returned to their previous level of dance upon completing physical therapy.

DISCUSSION

Dance is distinct from other team sports that commonly cause musculoskeletal injuries, as there is not an off-season, there are no on-field substitutions, and athletes cannot rely on other team members to compensate for their performance. Therefore, many injuries to dancers lack a specific inciting, traumatic event but rather develop from overuse, often preceding a competition or performance that demands an increase in training. According to several reviews in the literature,[28-30] overuse injuries constitute nearly 75% of all injuries among dancers across the various disciplines of ballet and are more prevalent in younger female dancers. Faults in positioning can force dancers to develop chronic compensation behaviors for certain biomechanical demands. This leads to muscular imbalance and strength deficits that, when combined with complex movements, can ultimately predispose dancers to lower extremity injuries while they are developing new technique.[1,22]

The purpose of this study was to determine clinical outcomes and successful return to sport in dancers after open surgery. As hypothesized, patients demonstrated significant improvement according to various PRO measures. Specifically, PROs regarding pain interference with daily activities and functional limitations were vastly improved upon completion of physical therapy. Despite a significant improvement in subjective pain ($P = .0004$) and functional daily activities, residual symptoms were common, as patients still reported pain (VAS of 1.73) and there was an 83% satisfaction rate postoperatively. Several dancers in this study were postoperatively diagnosed with adjacent FHL pathology, and an open posteromedial approach was the predominant method used, as it permitted treatment by debridement or further repair of the FHL.[7,14] Additionally, open posteromedial approach presents a lower complication rate when compared with open posterolateral or endoscopic methods.[24] It has been demonstrated that a specific rehabilitation program aids considerably to a safe and timely return to dance.[7,10] Dancers initiate therapy after 2 weeks with an anticipated modified return to sport at 6 weeks postoperatively. Complications in this study included temporary sural nerve neurapraxia, discomfort from scar tissue buildup that resolved through therapy, and mild peroneus brevis tendinitis as a result of mechanical compensation.

Including the patient's date of last follow-up rather than a discrete data point postoperatively can introduce variability, as individuals may reach their maximum relief in symptoms but not report it until returning for another unrelated issue months later. Choosing a discrete point (eg, 6 months) for tracking patient outcomes is a more direct way of measuring outcomes. However, we believe that capturing data at the patient's latest follow-up is more realistic for tracking the overall outcome from the procedure over time. For example, many patients reported near-maximal improvement at 6 weeks postoperatively, but continued to gradually improve until their last follow-up appointment several months or years later, representing the endpoint in the study. It is also difficult to discern an acute inciting event from a worsening of chronic instability that causes PAIS. The difference in etiology may affect recovery time or be considered a risk factor for contralateral symptomatic os trigonum, but this was beyond the scope of our present study. Additionally, a better understanding of etiology will help to educate the clinician as to possible interventions if a dancer presents with early symptoms.

Owing to the significant number of ankle injuries in dancers in general, there is a need for improved prepointe screening and en pointe training protocols, as this often represents the crucial timepoint for developing techniques that minimize a dancer's risk of an eventual injury.[2] As such, preventative measures can be taken in cases of PAIS that result from chronic compensation behavior for poor mechanics. After determination for pointe readiness has been made, subsequent evaluation for proper footwear is needed. Standard pointe shoes include a reinforced sole (shank) with layers of rigid material that provide arch support while en pointe. Differences in the material of the shank (leather, cardboard, and plastic), length (full, three-quarter, and half), or longevity could also explain the causes of chronic instability that predispose a dancer to PAIS. Unsurprisingly, pointe shoes that have been used beyond the point of proper stability can result in measurable, injurious biomechanics of the surrounding musculature.[3,5] A proper understanding of a dancer's demands and potential for technical faults allows for a more accurate diagnosis of true impingement and candidacy for surgical discussion.

CONCLUSION

Complex ankle injuries are common in the dance population and are significantly restrictive to daily training and competition. Posterior impingement arises from both osseous and soft tissue etiologies but often goes underrecognized despite being common in dancers and well-characterized in the literature. Surgery via open approach to remove a symptomatic os trigonum allows the majority of athletes to return to their sport of choice within weeks and with minimal complications. In this study, dancers of varying levels and primary styles improved significantly according to various clinical measures and maintained thriving postoperative careers. Successful return to dancing relied greatly on well-structured rehabilitation, with a dedicated physical therapy team working with the dancer both before and after surgery.

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