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Original Article

Clinical Effects of Tibial Posterior Tendon Reconstruction in the Treatment of Young Athletes With Accessory Navicular Bone Syndrome

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Abstract

Objective: To compare the effects of anchor reconstruction of posterior tibial tendon with the traditional Kidner's procedure for accessory navicular bone syndrome. **Methods**: A retrospective analysis was conducted on 40 young athletes diagnosed with accessory navicular bone syndrome who were admitted to our hospital from 2018 to 2021. Among them, 20 patients underwent the modified Kidner procedure for the anchor reconstruction of the posterior tibial tendon (Experimental group), while the remaining 20 patients were treated with the traditional Kidner's procedure (Control group). Regular follow-ups were conducted to evaluate the degree of relief of foot symptoms and functional recovery. **Results**: All patients were followed up for 12 to 24 months (mean duration: 18.6±3.7) after the operation. At the last follow-up, significant differences were observed in the function and symptom relief of the affected foot compared to the preoperative state. The experimental group had a mean operation time of 52.10 ± 3.41 minutes, significantly shorter than the control group's 61.25 ± 2.75 minutes. The mean time to return to normal activity was 12.65 ± 1.23 weeks for the experimental group, compared to 15.25 ± 1.16 weeks for the control group. **Conclusion**: The modified Kidner procedure demonstrates a higher patient satisfaction rate compared to the traditional Kidner procedure. This is attributed to its shorter duration, reduced trauma, and quicker recovery of normal activity.

Keywords: Accessory Navicular Bone Syndrome, Posterior Tibial Tendon

Introduction

The accessory navicular bone is a supernumerary bone in the foot. It is a congenital malformation, and further studies are needed to determine its potential genetic factors[1]. The primary clinical manifestations of the accessory navicular bone syndrome include pain and limitation of foot function. Pain and tenderness resulting from the presence of the accessory navicular bone are mainly distributed in the medial arch of the foot, and patients typically experience exercise-related intermittent pain[2,3]. The condition often affects both feet rather than just one and tends to appear symmetrically. The presence of the accessory navicular bone is reported to range from 4% to 14%, and it tends to occur in both feet more frequently than in a single foot[4]. This condition is closely associated with the development of flat feet and is considered a significant contributor to its occurrence. Several factors contribute to the pain on the inside of the foot, including the softness of shoe wear, foot trauma, and the intensity of regular exercise[5]. Young athletes, due to the demands of their athletic pursuits, engage in prolonged and high-intensity sports training, such as climbing, long-distance running, and weight-bearing activities. Consequently, the incidence of accessory navicular bone syndrome is more prevalent among these individuals[6,7]. Furthermore, the majority of patients exhibit

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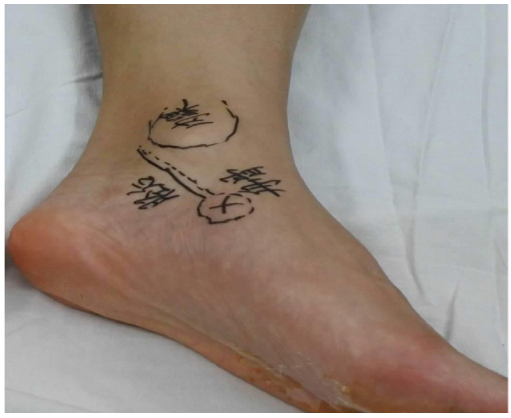

Figure 1. Incision design.

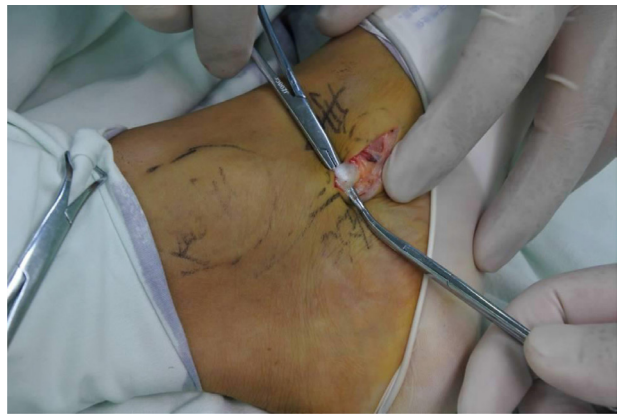

Figure 2. Expose the posterior tibial tendon.

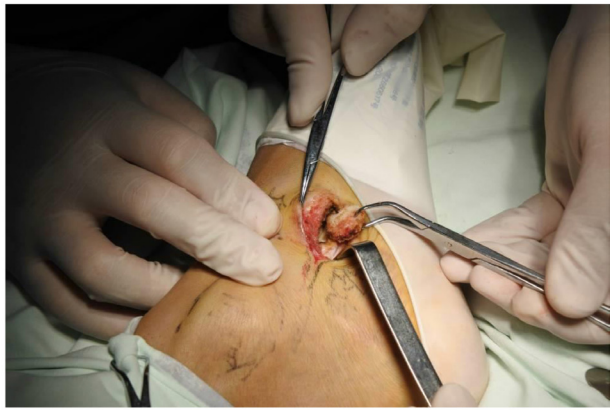

Figure 3. Completely remove the accessory navicular bone.

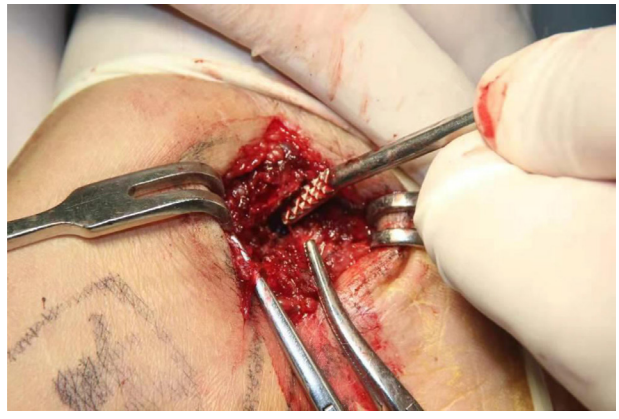

Figure 4. Fresh the hardened bone.

recurrent and persistent symptoms. Following extended conservative treatments, those with inadequate responses often opt for surgical intervention[8-10].

At present, there are many clinical surgical methods, but there is no unified standard surgical method, which poses some obstacles to the treatment of accessory navicular bone syndrome[11]. This study is to see which method is optimal by comparing the posterior tibial tendon anchor reconstruction with the traditional kidner surgical approach for the treatment of accessory navicular bone syndrome.

Methods

Data collection

By means of questionnaires and follow-up, we retrospectively collected medical records from patients with accessory navicular bone syndrome admitted to our hospital between August 2018 and June 2021. We ensured that all the collected cases underwent conservative treatment for a minimum of 24 weeks. All patients experiencing foot pain and functional limitations underwent non-surgical treatment measures, such as foot immobilization and physical therapy, for a duration exceeding 6 months.

A total of 40 young athletes with type II accessory navicular bone syndrome (according to the Dwight classification[12,13]) were included in the study, all of whom exhibited unilateral involvement. The patients were all young male athletes, with an average age of (20.6±3.7) years, ranging from 17 to 25 years. Foot X-ray examinations were performed at 1, 2, and 3 months after surgery, followed by subsequent evaluations every 3 months post-surgery.

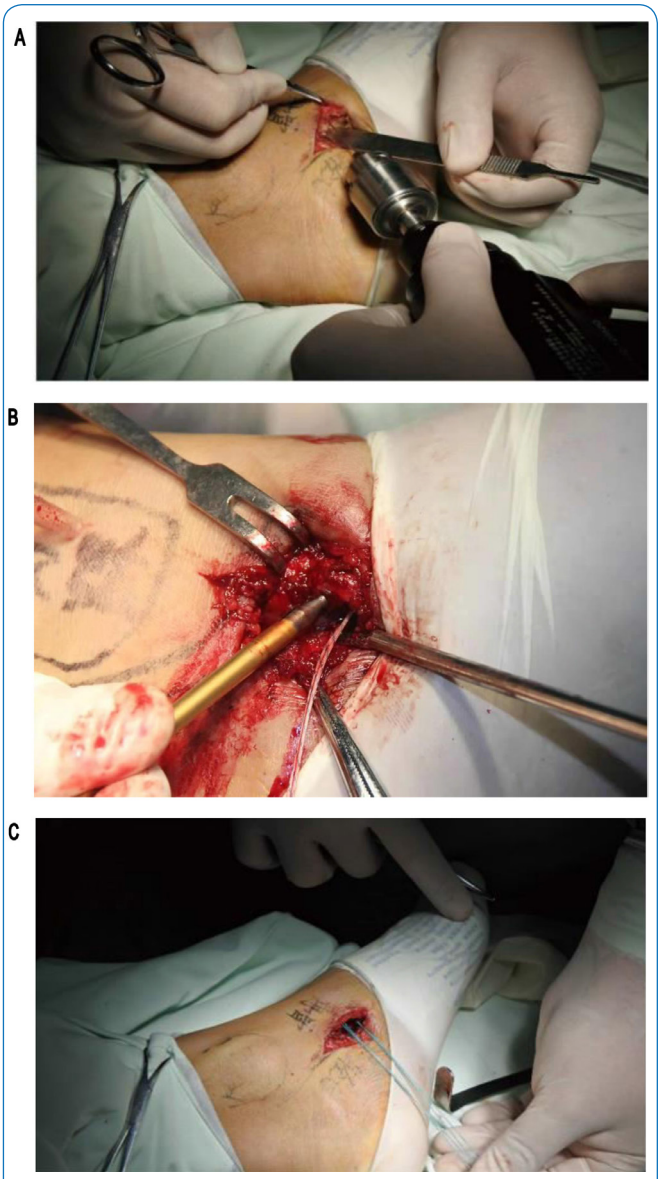

Figure 5. A: Drill with Kirschner wire, B: Implant the Revo/Mini-Revo anchor, C: Revo/Mini-Revo anchors had been implanted in the navicular bone.

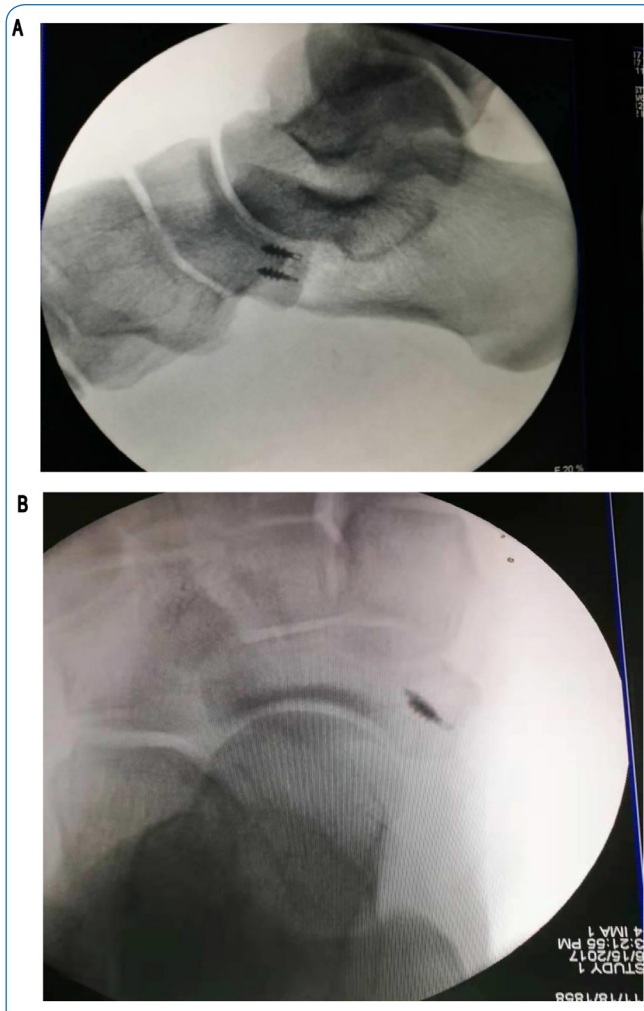

Figure 6. A: Intraoperative X-ray at lateral position, B: Intraoperative X-ray at frontal position.

Operative approach

In the **experimental group** (The modified Kidner procedure), either lumbar anesthesia or epidural anesthesia was employed as the method of anesthesia. All patients were positioned supine. After applying a tourniquet to the lateral thigh root post-anesthesia, the operation area underwent disinfection with iodine and alcohol. Following sterile draping, a vice accessory navicular bone was highlighted as the center for incision selection. A longitudinal incision, approximately 2 to 4 cm in length, was made along the direction of the posterior tibial tendon contortion (Figure 1). The incision traversed the skin, subcutaneous tissue, deep fascia, and longitudinally split the tendon, fully exposing the accessory navicular bone (Figure 2).

Bilateral dissection of the accessory navicular bone ensued, with careful protection of the posterior tibial tendon to prevent collateral injury. The complete removal of the scaphoid bone (Figure 3) was followed by a thorough cleaning of the synovium, joint capsule, and cartilage tissue between the accessory navicular bone and the navicular bone itself. The accessory navicular bone was trimmed to the medial level of the cuneus, ensuring no apparent uplift upon skin coverage.

Using a sclerosing bone file, the medial metatarsal surface of the navicular bone was ground until a fresh bone surface oozed blood (Figure 4). Special attention was given to retaining a certain amount of cortical bone to enhance the anchor's holding force. Two anchors were then implanted into

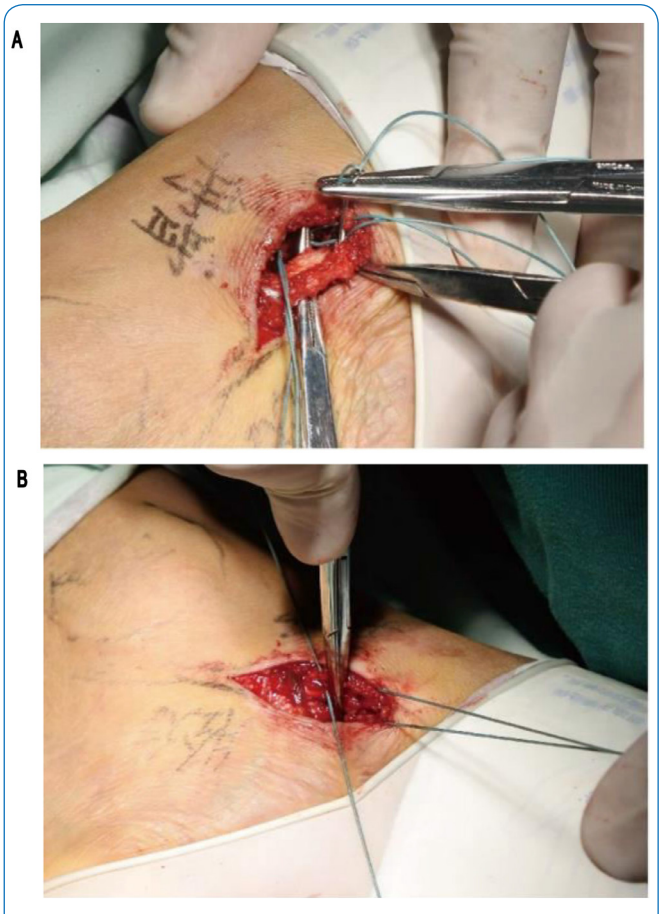

Figure 7. A: Suture the posterior tibial tendon, B: The posterior tibial tendon was sutured on the fresh navicular bone surface.

the medial metatarsal bone treatment area of the scaphoid (Figures 5-6). Subsequently, the anchor's suture was passed through the posterior tibial tendon using a common suture needle. The posterior tibial tendon was firmly and stably fixed to the treatment area of the medial metatarsal surface of the scaphoid through the anchor's suture (Figure 7).

In the **control group** (The traditional Kidner procedure), the method of anesthesia involved either lumbar or epidural anesthesia, and all patients were placed in a supine position. Post-anesthesia, a lateral thigh root pressure tourniquet was applied, followed by disinfection of the operation area with iodine and alcohol. Sterile drapes were used, and a vice scaphoid was highlighted as the center for incision selection. A longitudinal incision, approximately 2 to 4 cm in length, was made along the direction of the contorted posterior tibial tendon, cutting through the skin, subcutaneous tissue, deep fascia, and longitudinally splitting the tendon. This exposed the pair of scaphoids, and bilateral dissection of the accessory navicular bone ensued. Care was taken to protect the posterior tibial tendon to avoid collateral injury.

Complete removal of the navicular bone was performed, followed by a thorough cleaning of the synovium, joint capsule, and cartilage tissue between the scaphoid bone and the scaphoid itself. The scaphoid bone was then trimmed to the medial level of the cuneus, ensuring no obvious uplift upon skin coverage. Using a sclerosing bone file on the medial metatarsal surface of the navicular bone, the bone was ground until a fresh bone surface oozed blood.

Additionally, two bone holes were drilled from the dorsal side of the scaphoid to the metatarsal side with a fine Kirschner wire. The posterior tibialis tendon was sutured to the metatarsal side of the scaphoid tubercle through the two holes in the scaphoid.

Evaluation Indicators:

- American Orthopaedics Foot and Ankle Society (AOFAS) Midfoot Scale[14]
- Visual Analog Scale (VAS)
- Calcaneal Inclination Angle (CIA)
- Angle between Talus and Calcaneus in lateral radiographs (ATC)
- Angle of the First Metatarsal in lateral radiographs (L-AFM)
- Angle of the First Metatarsal in anteroposterior radiographs (AP-AFM)
- Talonavicular Coverage Angle (TCA)
- Operation time
- Postoperative time to normal activity
- Postoperative excellent rate

Statistical analysis

Statistical analysis was conducted using SPSS 25 software. For normally distributed data, results are presented as mean ± standard deviation. The comparison between groups was performed using the two independent samples t-test. The $\chi 2$ test was employed for count data comparison. $P<0.05$ was considered statistically significant difference.

Results

All patients were followed up for a duration ranging from 11 to 18 months, with an average follow-up period of (13.6±3.7) months. The incisions for all patients healed without exudation or other discomfort.

Comparison of various evaluation indexes between the two groups before surgery

Comparison of Various Evaluation Indexes Before Surgery:

Upon analyzing the preoperative evaluation indexes of both groups, statistical analysis revealed no significant differences between the two groups (Table 1).

Comparison of Evaluation Indexes at the Last Follow-Up After Surgery:

Upon analyzing the final follow-up indexes of both

Table 1. Comparison of various evaluation indexes before surgery.

	Experimental group (n=20)	Control group (n=20)	*P*
AOFAS	45.70±2.23	46.10±1.55	0.514
VAS	5.10±0.91	4.75±0.79	0.201
CIA	21.5±1.05	20.95±0.887	0.082
ATC	38.45±1.28	38.85±1.040	0.248
L-AFM	6.55±1.05	6.30±1.218	0.491
AP-AFM	13.15±1.23	13.20±0.951	0.886
TCA	13.55±1.47	14.30±1.031	0.069

Table 2. Comparison of evaluation indexes at the last follow-up after surgery.

	Experimental group (n=20)	Control group (n=20)	*P*
AOFAS	87.60±2.186	87.20±1.881	0.539
VAS	1.10±0.447	1.15±0.366	0.701
CIA	25.70±1.625	25.90±1.294	0.669
ATC	34.15±1.268	34.10±0.968	0.889
L-AFM	12.8±1.473	12.00±1.864	0.14
AP-AFM	9.35±1.755	10.30±1.261	0.057
TCA	10.65±1.424	11.45±1.234	0.065

Table 3. Comparison of preoperative and last postoperative follow-up evaluation indexes between the two groups.

	Preoperative	The last follow-up	*P*
AOFAS			
Experimental group	45.70±2.23	87.60±2.19	<0.05
Control group	46.10±1.55	87.20±1.88	<0.05
VAS			
Experimental group	5.10±0.91	1.10±0.45	<0.05
Control group	4.75±0.79	1.15±0.37	<0.05
CIA			
Experimental group	21.5±1.05	25.70±1.63	<0.05
Control group	20.95±0.89	25.90±1.29	<0.05
ATC			
Experimental group	38.45±1.28	34.15±1.27	<0.05
Control group	38.85±1.04	34.10±0.97	<0.05
L-AFM			
Experimental group	6.55±1.05	12.8±1.47	<0.05
Control group	6.30±1.22	12.00±1.86	<0.05
AP-AFM			
Experimental group	13.15±1.22	9.35±1.76	<0.05
Control group	13.20±0.95	10.30±1.26	<0.05
TCA			
Experimental group	13.55±1.47	10.65±1.42	<0.05
Control group	14.30±1.03	11.45±1.23	<0.05

Table 4. Comparison of operation time and postoperative recovery time between the two groups.

	Experimental group	Control group	*P*
Operation time (min)	52.10±3.42	61.25±2.75	<0.05
Time to recovery after surgery(W)	12.65±1.23	15.25±1.16	<0.05

Table 5. Postoperative satisfaction evaluation.

	Excellent (n)	Good (n)	Acceptable(n)	Bad (n)	The excellent and good rate %	*P*
Experimental group	16	3	1	0	95	<0.05
Control group	15	2	2	1	85	

groups, the statistical analysis revealed no significant differences between the two groups (Table 2).

Comparison of Preoperative and Last Postoperative Follow-Up Evaluation Indexes Between the Two Groups:

Statistical analysis revealed differences between the preoperative and last follow-up indicators in both groups. Both the experimental and control groups showed improvement in the preoperative indicators (Table 3).

Comparison of Operation Time and Postoperative Recovery Time Between the Two Groups:

Statistical analysis found significant differences in operation time and postoperative recovery time between the two groups. The operation time in the experimental group was shorter than that in the control group, and the postoperative recovery time in the experimental group was also faster (Table 4).

Postoperative Satisfaction Evaluation

Patients were assessed based on criteria such as foot pain, the ability to wear specific shoes, engagement in activities, and the extent of any disruptions. Classification categories included excellent, good, acceptable, and poor. The results indicated that both groups achieved high satisfaction levels post-surgery, with the experimental group demonstrating even higher satisfaction (Table 5).

Discussion

The primary clinical symptoms associated with the accessory navicular bone are pain and limited foot function. These symptoms are typically induced by strain and depression of the medial longitudinal arch[15]. In cases where the foot undergoes a vice scaphoid mutation, it can lead to alterations in the normal course of the posterior tibial tendon. The noticeable variations in the course and attachment point of the posterior tibial tendon have a direct or indirect impact on the tension exerted by the tendon, influencing the maintenance of the medial arch of the foot in terms of anatomical structure and biomechanics[16,17]. Significant changes in the structure and position of the attachment or insertion point of the posterior tibial tendon result in repetitive traction and stimulation of the scaphoid bone. Over time, this process leads to the formation of unstable fibrous tissue connecting the scaphoid bone and the posterior tibial tendon[18]. Moreover, for young athletes, wearing hard uppers and engaging in high-intensity exercise or training can lead to the repeated friction of the abnormally elevated scaphoid bone, causing local bursitis. This, too, is identified as one of the causes of pain in the medial arch of the foot[7]. Additionally, cystic changes are evident between the accessory navicular bone and navicular bone[19,20]. According to relevant literature reports[7], The accessory navicular bone can be divided into three types. Type I patients typically exhibit fewer clinical symptoms of medial foot pain, with only round sesamoid changes visible in the medial tendon through X-ray and MRI examinations[15,16]. In contrast, type II patients experience more severe clinical symptoms. Imaging examinations, including X-ray, CT, and foot MRI, reveal the formation of a pseudojoint between the scaphoid bone and the accessory scaphoid, with a fibrous cartilage connection between the two. This connection is prone to local injury, traction, or shear force injuries following repeated grinding. In patients with type iii, imaging examinations reveal partial or complete fusion between the navicular bone and the accessory navicular bone, categorized as either beak type or angular bone type. Among the three types mentioned, type ii is the most common, characterized by painful accessory navicular bone often accompanied by deformities. In type II patients, the unstable articular surface between the navicular bone and the accessory navicular bone leads to prolonged friction, causing local cystic changes and resulting in pain on the

medial side of the foot.

The cases collected in this study all exhibited persistent medial foot pain, directly attributed to long-term direct or indirect damage to the medial side of the foot. Imaging examinations highlighted that focal necrosis and inflammation were consequences of the accessory scaphoid malformation, contributing to prolonged foot pain symptoms. The delay in addressing this inflammation underscores the significance of surgery as the only effective and radical treatment strategy for accessory navicular bone syndrome, as conservative treatments may not offer a cure.

At present, numerous surgical methods are discussed in the literature. The most common types of surgical procedures include Kidner surgery and modified Kidner surgery, simple resection, modified simple resection, percutaneous drilling, internal fixation and fusion, and combinations involving tenoscopy, among other surgical techniques[21,22]. Accessory navicular bone syndrome is more prevalent in type II, constituting over 90% of cases with medial foot pain and limited foot function and activity[23,24]. A systematic evaluation study[25] found that traditional Kidner surgery and simple resection of accessory navicular bone surgery can achieve good clinical effects, with no significant difference. However, the article mentioned that traditional Kidner surgery takes a long time. Therefore, we made improvements based on traditional Kidner surgery, applying anchors to reduce the time spent on the navicular bone operation.

The traditional kidner operation and the modified operation mainly involve the removal of the necrotic accessory navicular bone and re-fixation of the posterior tibial tendon in the navicular bone. The advantage of this operation is the enhanced tension of the posterior tibial tendon after the procedure, restoring the mechanical direction of the tendon during the operation, which can effectively maintain the elasticity of the arch support system. However, this operation may cause damage to the elastic arch support system. The establishment of a bone tunnel during the operation can lead to significant damage to the scaphoid bone, and the precise control of operating depth becomes challenging, increasing the risk of fractures. These complications may result in adverse consequences, such as poor fixation point stability and postoperative tendon loosening. Additionally, the extension of postoperative external fixation time significantly impacts the optimal timing for functional rehabilitation exercises of the affected foot after surgery[26].

In recent years, significant advancements in science and technology have brought about substantial changes in medical biomaterials technology and biomechanics research. The emergence of new medical consumable materials, particularly anchors, has revolutionized the treatment of torn tendons, ruptures, post-traumatic reconstruction, and repairs in the human body. Of the cases available in this study, Revo/Mini-revo 3.2 mm suture anchors were utilized for the reconstruction of the posterior tibial tendon insertion[27,28]. To a large extent, this method effectively addresses the limitations of the previously mentioned methods. In each case, scaphoid resection was initially performed with utmost care to protect the posterior tibial tendon during the operation. The articular surface, hardened by the scaphoid, and the pseudojoint formed by the accessory navicular bone, were meticulously polished with a bone file until blood oozed out. This process significantly promoted the fusion of the insertion point of the posterior tibial tendon and the scaphoid bone. The Revo/Mini-revo 3.2mm anchor was then strategically placed on the medial metatarsal of the scaphoid. Leveraging the unique design of the anchor and its thread principle, the pull tension exerted on the scaphoid bone is evenly distributed across each contact surface. This approach maximizes the involvement of surrounding bone tissue in mechanical conduction, ensuring a robust fixation of the tibial posterior tendon. This, in turn, effectively alleviates and improves aseptic inflammatory reactions caused by excessive local tension moments during conduction between the tibial posterior tendon tissue and bone tissue. Moreover, it helps prevent postoperative issues such as the detachment of the tendon from the bone junction and other related adverse reactions. The posterior tibial tendon was sutured using a braided suture on the Revo/Mini-revo 3.2mm anchor. This approach facilitated a more effective recovery of strength and tension in the tendon, ensuring stable restoration and maintenance of the elastic arch. Additionally, it effectively prevented related complications, such as valgus and secondary flat foot.

In our study, the modified Kidner procedure showed a VAS score of 1.10 ± 0.447 and AOFAS score of 87.60 ± 2.186, while the conventional Kidner procedure exhibited a VAS score of 1.15 ± 0.366 and AOFAS score of 87.20 ± 1.881, with no significant difference observed. This indicates that both procedures can achieve positive outcomes in improving foot function and alleviating symptoms. The mean operation time for the modified Kidner procedure was 52.10 ± 3.42 minutes, with a mean recovery time to normal activity of 12.65 ± 1.23 weeks and a postoperative satisfaction rate of 95%. For traditional Kidner surgery, the mean operation time was 61.25 ± 2.75 minutes, the postoperative recovery time to normal activity was 15.25 ± 1.16 weeks, and the postoperative satisfaction was 85%. These results demonstrate that the modified Kidner surgery can effectively reduce the operation time due to the anchor's stability and less bone damage, thereby enhancing patient satisfaction (excellent rate).

In conclusion, Revo/Mini-Revo anchor posterior tibial tendon reconstruction is well-suited for the majority of patients with type II painful accessory navicular deformity who have not experienced relief of foot symptoms despite more than six months of local physiotherapy, non-steroidal analgesics, and other non-surgical treatments. The surgical procedure involves the removal of the necrotic accessory navicular bone with inflammation, strengthening of the posterior tibial tendon using the inherent suture of the Revo/Mini-Revo anchor, and re-fixation on the medial side of the scaphoid toe. The bone file is then used to create a fresh wound, effectively eliminating the pseudoarticular surface, and promoting the fusion of the posterior tibial tendon with

the bone in the selected re-fixed area. The procedure offers several advantages: (1) Reduced intraoperative trauma and significantly shortened operation time; (2) Minimal alteration in the hanging mechanism of the elastic arch, maintaining its integrity; (3) Shortened postoperative recovery time; (4) Minimized hospital stay, leading to cost savings for patients and reduced medical resource utilization. This operation proves highly effective and feasible for patients with type II painful scaphoid deformity, providing pain relief and improved foot function. While modified tibial posterior tendon reconstruction has shown clinical efficacy in treating scaphoid pain, the limited number of observed cases warrants further investigation. Basic research and long-term follow-up are necessary to explore the effects on tension changes, healing time at the bone-tendon interface, disease progression, and biomechanical alterations resulting from posterior tibial tendon reconstruction and its impact on the entire arch.

Ethics approval

The study was approved by the Bethune International Peace Hospital ethics committee 2023-ky-196.

Authors' contributions:

YW and YH designed the study and drafted the manuscript. XS and LJ were responsible for the collection and analysis of the experimental data. XP, YZ and QK revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

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