Anatomical footprint reconstruction for the treatment of insertional Achilles tendinopathy with heterotopic ossification

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Abstract

Background

The aims of this study were to investigate the clinical outcomes of anatomical footprint reconstruction for the treatment of insertional Achilles tendinopathy (IAT) with heterotopic ossification and to provide an effective surgical method for the treatment of this condition.

Methods

From October 2016 to October 2019, 10 patients underwent anatomical footprint reconstruction for the treatment of IAT with heterotopic ossification at our institution. The operation time and intraoperative bleeding volume were recorded. X-ray and MRI examinations of the calcaneus were performed after the operation. The American Orthopaedic Foot and Ankle Society (AOFAS), visual analog scale (VAS) and Victorian Institute of Sports Assessment–Achilles (VISA-A) scores were used to evaluate the clinical effects on the patients; the time to normal walking and exercise recovery was recorded; and the recovery rate of exercise was recorded at 6 months after the operation.

Results

The average operation time was 64.4 min (45-74 min), the average bleeding volume was 29.7 ml (5-100 ml), and the average follow-up time was 22.4 months (12-48 months). The patients' wounds healed without infection, splitting, necrosis of the skin margin or other complications. The mean AOFAS score (± SD) was 70.3 ± 11.39 preoperatively and 94.2 ± 5.00 at the last follow-up, showing a significant difference between timepoints (P = 0.00; t = 7.657). The VAS score was 5.4 ± 1.71 preoperatively and 0.4 ± 0.51 at the last follow-up; this decrease was statistically significant (P = 0.00; t = 11.859). The mean VISA-A scores at the preoperative baseline and the last follow-up were 37.6 ± 16.39 and 81.4 ± 8.83, presenting a significant difference between the two timepoints (P = 0.00; t = 9.906). The average time to recover normal walking ability was 9.1 weeks (4-15 weeks), and the average time to resume exercise was 10 weeks (8-12 weeks). At 6 months after the operation, the rate of exercise recovery was 80%.

Conclusion

In IAT with heterotopic ossification, anatomical footprint reconstruction enables patients to return to normal life and exercise quickly. The rate of return to sports is high, and the procedure offers satisfactory clinical effects.

Background

Insertional Achilles tendinopathy (IAT) is a chronic injury that occurs within 2 cm of the calcaneal insertion of the Achilles tendon[1]. This condition is often a result of long-term excessive by the patient, which leads to overuse of the insertional part of the Achilles tendon. IAT can also occur as part of the degenerative changes that take place in older patients[1, 2]. Common pathological changes associated with IAT include steatosis, calcification, and heterotopic ossification at the insertion of the Achilles tendon, which causes pain, swelling of the heel and limited ankle joint function[3, 4]. At present, the relative merits of different treatment methods are controversial; treatments include reducing exercise, centrifugal movement of the Achilles tendon, nonsteroidal anti-inflammatory drugs (NSAIDs), ultrasonic treatment, local nerve blockade, and platelet-rich plasma (PRP) treatment, among others. However, the effect is often not ideal, and the disease is frequently recurrent[5–7]. When conservative treatment is ineffective, surgical treatment is needed. Various surgical treatments can be applied at the insertion of the Achilles tendon, including arthroscopic treatment, radiofrequency ablation, and detachment from the bone followed by reattachment with a wire anchor[8, 9]. The clinical effects reported in the literature are variable, and patients are prone to relapse after resuming exercise[10, 11].

Heterotopic ossification of the Achilles tendon insertion is a common pathological manifestation of insertion Achilles tendinopathy. For patients with severe ossification of the distal insertion of the Achilles tendon, it is often necessary to detach the tendon from the calcaneus, remove the heterotopic ossification, and then reattach the tendon to the calcaneus[12]. Reports on patient recovery and clinical effects vary greatly, and patients are often greatly delayed in their return to sports[13–15]. The insertion of the Achilles tendon is commonly reconstructed with a single or double row of anchors. However, following single-row anchor reconstruction, there is only a linear zone of attachment between the Achilles tendon and the calcaneus. In the early postoperative period, the resistance to pull-out is not high, and the joint often needs to be fixed with a plaster cast, which usually causes ankle joint stiffness and a high risk of Achilles tendon rerupture. Double-row reconstruction has good initial stability, but the current methods do not consider the shape of the footprint that the Achilles tendon forms on the calcaneus; therefore, the biomechanical properties of the Achilles tendon may change after reconstruction, delaying the patient’s return to sports[15–18].

In the treatment of IAT with heterotopic ossification, anatomical footprint reconstruction has always been the goal of surgeons. The Achilles tendon is attached to the gastrocnemius muscle and the soleus muscle. The tendon rotates en route to its distal footprint on the calcaneus; this configuration may be related to the biomechanical properties of the Achilles tendon[19, 20]. In IAT with heterotopic ossification, it is very important to dissect the footprint of the tendon to reconstruct it, which may improve clinical outcomes. Therefore, this study was performed to evaluate the clinical outcomes of anatomical footprint reconstruction for IAT with heterotopic ossification; to observe how long patients took to resume normal

life and to return to sports; and to measure the rate of return to sports at 6 months postoperatively, all with the goal of providing an effective surgical method to treat this chronic condition.

Materials And Methods

From October 2016 to October 2019, 10 patients who underwent footprint anatomical reconstructive operations for IAT with heterotopic ossification were recruited in our department. The sample contained 9 males and 1 female with an average age of 49.4 years (28-70 years). Before the operation, X-rays of the calcaneus and magnetic resonance imaging (MRI) of the Achilles tendon were performed to confirm the diagnosis (Table 1).

The inclusion criteria were as follows: (1) patients who suffered from IAT with heterotopic ossification and did not benefit from 6 months of conservative treatment or more than 50% rupture of the Achilles tendon; (2) patients who underwent footprint anatomical reconstructive operations.

The exclusion criteria were as follows: (1) patients with systemic diseases (ankylosing spondylitis, rheumatoid arthritis, etc.) accounting for the destruction of the Achilles tendon insertion; and (2) a follow-up period of less than 12 months.

Surgical technique

The operation was performed under lumbar plexus sciatic nerve anesthesia, epidural anesthesia, subarachnoid anesthesia or general anesthesia. The patient was in a prone position. A tourniquet was applied at the base of the thigh. An incision was made through the skin to the depth of the striated muscle. The incision began 0.5 cm medial to the Achilles tendon, 5 cm proximal to its insertion, and ran distally in parallel to the tendon; it then turned to the lateral side in an “L” shape and ended at the outer edge of the calcaneus. After incising the skin and subcutaneous tissue, the surgeon longitudinally split the distal end of Achilles tendon and its insertion point to expose and confirm the protruding ossification at the insertion point. The insertion of the Achilles tendon was debrided, and its footprint was marked. Then, the ossified tissue of the tendon was marked. An oscillating saw was then used to fully resect the exostosis. Two anchor screws (5.5 mm Healix Advance, DePuy Mitek) were screwed into the footprint proximal to the insertion of the Achilles tendon, perpendicular to the bone surface, spaced at one-third and two-thirds of the way from the medial edge to the lateral edge. The tail thread passed through the medial 1/3 and the lateral 1/3 of the footprint of the Achilles tendon and was sewn and knotted horizontally without cutting the suture. The suture was pulled to the distal side and used to press the free part of the distal Achilles tendon against the footprint of its insertion; then, two Versalok anchors (DePuy Mitek) were used to fix the suture at the distal edge of the footprint, spaced at one-third and two-thirds of the way from the medial edge to the lateral edge. The surgeon then closed the peritendinous membrane, sutured the subcutaneous tissue, and sutured the skin (Figures 1).

Postoperative rehabilitation

No plaster cast fixation was needed after the operation. After recovering from anesthesia, the patient could be asked to carry out non-weight-bearing activities with the ankle joint. The sutures were removed 2 weeks after the operation. At that time, the patient was allowed to carry out weight-bearing activities within tolerance. After 6 weeks, the patient can fully carry out weight bearing and gradually begin adaptive jogging exercise within tolerance.

Postoperative assessments

The operation time and intraoperative bleeding volume were recorded. The patients were followed up 6 weeks, 3 months, 6 months, 1 year and 2 years after the operation. The calcaneus was examined by X-ray and MRI. The clinical effect of treatment was evaluated in terms of the American Orthopaedic Foot and Ankle Society (AOFAS), visual analog scale (VAS) and Victorian Institute of Sports Assessment–Achilles (VISA-A) scores. The latencies to resume normal walking and exercise were recorded, and the exercise recovery rate was recorded at 6 months after the operation.

Statistical analysis

SPSS 26.0 software was used for statistical analysis. The data are expressed as the mean ± standard deviation (SD). A paired t-test was used to compare data from before and after the operation. The α level was set to 0.05.

Results

All patients in this group successfully completed the operation, with an average operation time of 64.4 min (45–74 min), an average bleeding volume of 29.7 ml (5-100 ml), and an average follow-up time of 19 months (6–42 months) (Table 1). The patients' wounds healed without infection, splitting, necrosis of the skin margin or other complications. The mean AOFAS score (± SD) was 70.3 ± 11.39 preoperatively and 94.2 ± 5.00 at the last follow-up, showing a significant difference between timepoints (P = 0.00; t = 7.657). The VAS score was 5.4 ± 1.71 preoperatively and 0.4 ± 0.51 at the last follow-up; this decrease was statistically significant (P = 0.00; t = 11.859). The mean VISA-A scores at the preoperative

baseline and the last follow-up were 37.6 ± 16.39 and 81.4 ± 8.83, presenting a significant difference between the two timepoints (P = 0.00; t = 9.906). The average time to recover normal walking ability was 9.1 weeks (4–15 weeks), and the average time to resume exercise was 10 weeks (8–12 weeks). At 6 months after the operation, the rate of exercise recovery was 80% (Table 2).

Discussion

IAT is a common sports injury, and its pathogenesis is not clear. It is often thought that excessive exercise causes repeated microinjury of the Achilles tendon, which can also be caused by degeneration or by abnormal development of the calcaneus, such as Haglund's deformity. The common pathological changes associated with IAT are fat deposition, heterotopic ossification, calcification, inflammation around the Achilles tendon and anterior bursitis of the Achilles tendon. For IAT patients with heterotopic ossification, the effect of conservative treatment is often not ideal, and surgical treatment is frequently needed. The purpose of the operation is to remove the ossification and calcification of the Achilles tendon and the inflammatory tissue around the tendon. In order to remove heterotopic ossification of the Achilles tendon, it is often necessary to detach the tendon at its insertion, cut away the heterotopic ossification, and reattach the tendon in its original position. It has been reported that the risk of Achilles tendon rupture after operation is small when the insertion is detached by less than 50%[2, 5], but when it is more than 50%, the risk of rupture is increased; in such cases, it is necessary to reattach the tendon with anchors at its insertion[1, 21, 22]. In this study, when the heterotopic ossification was being removed, the insertion of the Achilles tendon was completely detached and cleaned; the footprint of the tendon was reconstructed with anchors afterward. Patients' AOFAS, VAS, and VISA-A scores were significantly improved after the operation, indicating a good clinical outcome. The average time to recover normal walking ability was 9.1 weeks (4–15 weeks), and the recovery time of exercise ability was 10 weeks (8–12 weeks). The recovery rate of exercise was 80% at 6 months after the operation. All of the patients soon returned to ordinary daily activities and exercise.

There are many methods for treating IAT with heterotopic ossification. The usual method is to detach the Achilles tendon from the calcaneus, remove the heterotopic ossification, and reattach the tendon to the calcaneus. Johnson et al. [21]used a bone anchor to reattach the Achilles tendon after debridement of degenerated or calcified portions with a central tendon-splitting incision. The average follow-period was 34 months. The AOFAS score increased from 53 preoperatively to 89 at the last follow-up. Nunley et al. [23]reported the use of the central tendon-splitting technique with a posterior incision. They performed a retrospective analysis of 27 patients. Two 3.5 mm suture anchors were used for fixation. One patient developed superficial wound infection. After an average follow-up period of 4 years, the average AOFAS score was 96. At the 7-year follow-up, 96% of the patients were pain free. Zhuang et al. [15]reported that the central tendon-splitting approach was an effective surgical method for the treatment of Achilles tendon disease. However, there are no reports on reconstructing the footprint of the Achilles tendon on the calcaneus. After detaching the Achilles tendon and removing the osteophyte, the surgeon reconstructs the footprint of the tendon on the calcaneus with a suture bridge by placing anchors at the proximal vertex of the footprint and external screws at the distal vertex. These attachment points cause the detached Achilles tendon to adhere to its original anatomical footprint on the calcaneal tubercle to restore the anatomical form and function as much as possible. The mean AOFAS, VAS and VISA-A scores at the latest follow-up were 94.2 ± 5.00, 0.4 ± 0.51 and 81.4 ± 8.83, respectively. All of these measures were significantly improved compared with their preoperative values. This study had several strengths: first, the anatomical reconstruction of the footprint provides an increased contact area between the Achilles tendon and its footprint on the calcaneus, which promotes tendon–bone healing; second, the anatomical reconstruction of the footprint can provide increase the initial pull-out strength, which helps patients carry out early weight-bearing exercise; third, the anatomical reconstruction of the footprint can restore the anatomical morphology of the Achilles tendon to restore its function. The biomechanical properties of the Achilles tendon-calcaneus complex were restored, and the rate of Achilles tendon rerupture was effectively reduced.

The Achilles tendon consists of the gastrocnemius tendon and soleus tendon. The anatomical study of the Achilles tendon shows that the tendons of the soleus and the medial and lateral heads of the gastrocnemius are inserted into the posterior parts of the calcaneus. As the gastrocnemius and soleus tendons extending to the distal end, they internally rotate to some extent[24]. PeKala et al. [20]carried out a cadaver study and assessed the degree of rotation of the Achilles tendon, classifying each tendon as type I, type II or type III accordingly. These three classifications of internal rotation affected the biomechanical properties of the Achilles tendon, determining the level of stress that it sustained. The attachment points of the three component tendons also have an important influence on the mechanical properties of the Achilles tendon as a whole. Therefore, it is very important to reconstruct the footprint of the detached Achilles tendon on the calcaneus in the treatment of Achilles tendinopathy. In this study, an "L"-shaped incision posterior to the Achilles tendon was used to expose and remove the Achilles tendon enthesopathy, and the shape of the footprint of the Achilles tendon was marked. According to the shape of the footprint, internal and external anchors were implanted to reattach the Achilles tendon to the footprint area. The results showed that the average time to recover normal walking ability was 9.1 weeks (4–15 weeks), the time to recover exercise ability was 10 weeks (8–12 weeks), and the exercise recovery rate was 80% at 6 months postoperatively. The proportion of patients with excellent or good postoperative functional scores was 100%.

Heterotopic ossification in IAT is a common pathological manifestation affecting the insertion of Achilles tendon. Traditional surgical treatment methods detach the insertional Achilles tendon, remove the heterotopic ossified tissue, and then reattach the Achilles tendon to the calcaneal tubercle. Plaster fixation is often needed postoperatively, but it brings a high risk of rerupture, slow recovery, and functional implications such as a low rate of return to sports. Johnson et al. [21]suggested that, after the application of bone anchors from the posterior median approach to repair

the insertion of the Achilles tendon, the limb requires 3 weeks of non-load-bearing recovery. Deorio et al. [8]suggested that the injured limb should not bear weight within 3–5 weeks after operation according to the degree of detachment of the Achilles tendon; DeVries et al.[9] also advised that the injured limb should not bear weight within 3–5 weeks after the use of a bone anchor for reattachment of a surgically detached Achilles tendon. Wagner et al.[25] reported that, when a bone anchor is used to repair the reattached IAT, the limb requires a weight-free recovery period of up to 8 weeks. McGarvey et al.[22] used the posterior median approach to treat the Achilles tendon. After the removal of inflammatory tissue, the Achilles tendon was fixed at the insertion with bone anchor nails. For 2 months after the operation, the patients could not fully load the limb when walking. Three months after the operation, only 15 of 22 patients were fully able to perform normal work again, and 2 patients did not return to work at all because of continuous symptoms. Hardy et al.[14] studied 46 patients with IAT. After the Achilles tendon was completely stripped from the bone, the limb needed plaster fixation for 6 weeks, after which the patients wore Achilles tendon boots for weight-bearing walking. A total of 89.1% of patients had no pain while running, and 71.7% of patients were able to return to their premorbid activity levels. In recent years, there have been an increasing number of reports on the reconstruction of the Achilles tendon with double-row anchors, and the mechanical stability of this reconstruction technique has been improved, which has enabled patients to resume weight-bearing activities early and expedited their return to exercise. Research shows that, for patients with extensive tendon debridement, double-row Achilles tendon suture bridge technology has a biomechanical advantage over single-row anchorage sutures [26]. Rigby et al.[27] reviewed 43 cases of insertional Achilles tendon reconstruction treatment with suture bridge technology. The patients did not need plaster fixation after the operation and could bear weight early, at an average of 10 days after the operation. The average AOFAS score was 90 (65–100). The VAS score improved from 6.8 (2–10) to 1.3 (0–6). Forty-two cases (97.6%) were able to return to their daily activities. However, the double-row reconstruction did not consider the restoration of the Achilles tendon footprint, and its long-term effect is uncertain. Considering that the Achilles tendon is composed of three bundles of tendons rotating and twisting, we adopted the method of anatomical footprint reconstruction of the Achilles tendon insertion to restore the biomechanical properties of the Achilles tendon–-calcaneus complex as much as possible. This method provides high initial biomechanical strength after the operation, and no postoperative plaster fixation is required. Therefore, the patients can be ordered to carry out active non-weight-bearing exercises with the ankle joint soon after the operation; the incision sutures are removed 2 weeks after the operation, at which time the patients were allowed to bear weight within tolerance. After 6 weeks, the patients could gradually begin adaptive jogging exercise. In this group, the average recovery time of normal walking ability was 9.1 weeks (4–15 weeks), and the recovery time of exercise ability was 10 weeks (8–12 weeks). The exercise recovery rate was 80% at 6 months postoperatively. Thus, the procedure allowed rapid recovery and a return to exercise.

The shortcomings of this study include the small number of cases and the short follow-up time. Despite its limitations, this study provides a method for the treatment of IAT with heterotopic ossification. Large sample studies and biomechanical studies are needed to further confirm the therapeutic effect of anatomical footprint reconstruction of IAT.

Conclusion

Anatomical footprint reconstruction for IAT with heterotopic ossification can provide a rapid return to normal life and exercise, a high rate of return to exercise, and satisfactory clinical outcomes.

Abbreviations

IAT insertional Achilles tendinopathy

AOFAS American Orthopaedic Foot and Ankle Society

VAS visual analog scale

MRI magnetic resonance imaging

NSAIDs nonsteroidal anti-inflammatory drugs

PRP platelet-rich plasma

Declarations

Ethics approval and consent to participate

The current study was approved by the Ethics Committee of the First Affiliated Hospital of Army Medical University (Institutional Review Board Study Protocol: KY2020037).

Consent for publication

All patients enrolled into the study agreed to the use of the patients' data for research.

Availability of data and materials

All data and materials were in full compliance with the journal's policy.

Competing interests

All authors declare that they have no competing interests.

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Authors' contributions

All surgical procedures were performed by Kanglai Tang. Lin Ma, Binghua Zhou contributed to the statistical analysis and drafting of the manuscript. Xu Tao and Zhenyu Wang contributed to the radiographic assessment and data collection. Guo Zheng, Tao Xu, and Zhou BH contributed to the literature search and revision of the manuscript. Tang KL and Xu Tao contributed to the research design and revision of the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Patient Details

Case No	Sex	Age（yr）	Side	pre-operation duration （mo）	Operation time （min）	intraoperatve blood （ml）	Follow-up Time （mo）
1	M	33	R	48	56	30	48
2	F	62	R	12	60	10	45
3	M	69	R	72	73	5	27
4	M	52	L	24	74	50	25
5	M	28	L	1	45	100	26
6	M	47	L	4	65	5	23
7	M	47	L	48	65	30	19
8	M	49	R	168	72	20	13
9	M	37	R	6	68	5	12
10	M	70	R	3	66	10	12
Average		49.4±14.4		38.6±51.5	64.4±8.8	26.5±29.7	22.4±10.4

Table 2. Clinical Evaluation of Patients

Case No	AOFAS Score		VAS Score		VISA-A questionnaire		Return to work/life(mo)	Return to active (mo)
	Preoperative	Postperative	Preoperative	Postperative	Preoperative	Postperative		
1	79	100	5	0	46	92	4	6
2	66	90	6	1	30	64	12	14
3	75	97	4	0	57	82	15	26
4	70	88	7	1	24	80	12	14
5	47	90	8	1	14	82	7	9
6	75	100	6	0	28	77	8	10
7	70	90	5	0	34	89	8	10
8	58	97	7	1	26	72	13	25
9	88	100	3	0	64	92	4	6
10	75	90	3	0	53	84	8	10
Mean	70.3±11.39	94.2±5.00	5.4±1.71	0.4±0.51	37.6±16.39	81.4±8.83	9.1±3.75	13±7.11
P	P=0.00T=7.657		P=0.00T=11.859		P=0.00T=9.906			

Figures

Figure 1

The procedure of Surgical technique. a. "L" shape incision behind Achilles tendon. b. Cut skin and subcutaneous tissue, expose and confirm insertional Achilles tendon. c.The insertion of the Achilles tendon was debrided. d. An oscillating saw was then used to fully resect the exostosis.

e.Mark the footprint of Achilles tendon and locate the anchors. f. Two anchor screws were screwed into the footprint proximal to the insertion of the Achilles tendon, perpendicular to the bone surface, spaced at one-third and two-thirds of the way from the medial edge to the lateral edge. g. The tail thread passed through the medial 1/3 and the lateral 1/3 of the footprint of the Achilles tendon and was sewn and knotted horizontally without cutting the suture. h.The suture was pulled to the distal side and used to press the free part of the distal Achilles tendon against the footprint of its insertion; then, two Versalok anchors (DePuy Mitek) were used to fix the suture at the distal edge of the footprint, spaced at one-third and two-thirds of the way from the medial edge to the lateral edge. i. After suture the Achilles tendon, the surgeon was plantarflex and dorsiflex the ankle to test the initial stability of the Achilles tendon.

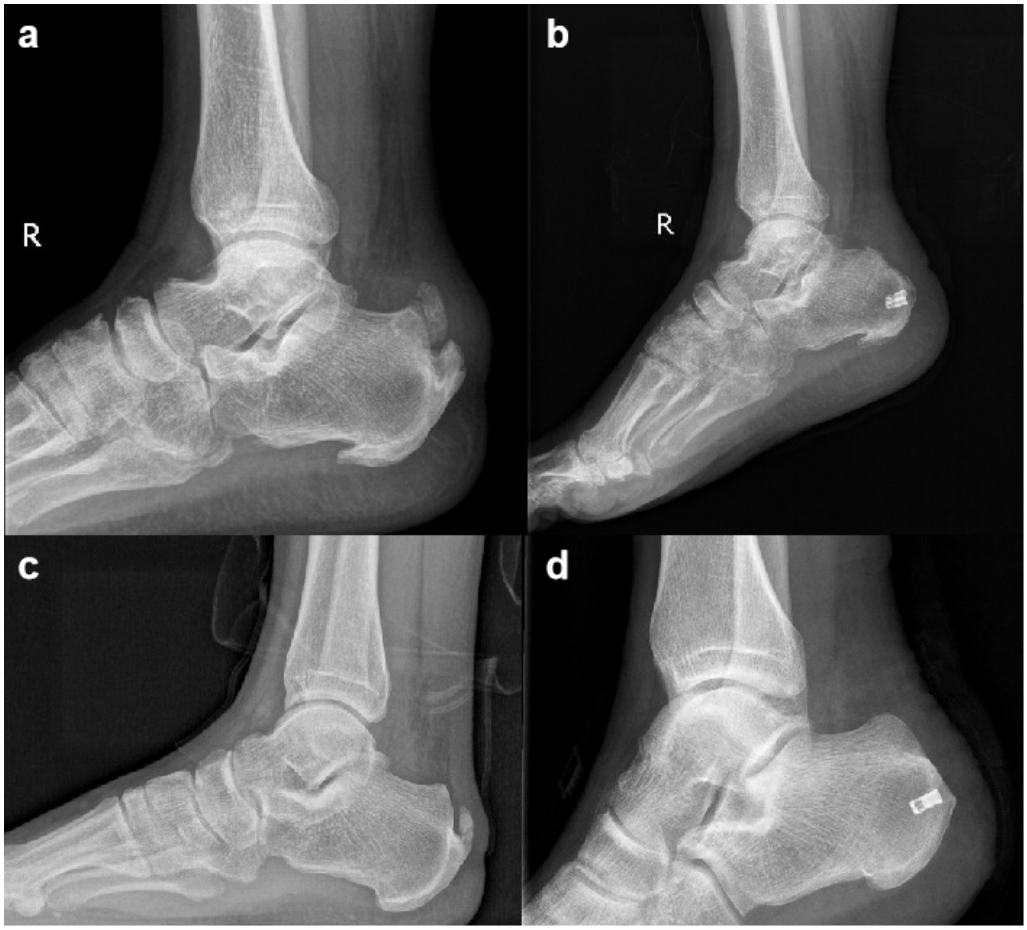

Figure 2

This was two typical cases: Before and after footprint anatomical reconstructive operations. a, c Lateral X-ray of calcaneus pre-operation; b,d Lateral X-ray of calcaneus post-operation