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Is an unresected subtalar joint a cause of failure in tibiotalocalcaneal arthrodesis with a nail?

Çivi ile tibiotalokalkaneal artrodezde subtalar eklemin rezeke edilmemiş olması başarısızlık nedeni midir?

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ABSTRACT

Aim: In this study, we aimed to evaluate clinical and functional outcomes of tibiotalocalcaneal arthrodesis (TTCA) using intramedullary nailing (IMN) without cartilage resection of the subtalar (ST) joint.

Methods: 22 ankles of 21 patients (one patient was bilateral), who underwent TTCA using IMN without cartilage resection of the ST joint in our clinic between January 2013 and December 2022 were retrospectively analyzed. Data including demographic and clinical characteristics of the patients, etiology, Kellgren-Lawrence classification, postoperative fusion rate, fusion status and complications were recorded. The European Quality of Life 5 Dimensions (EQ-5D) scores were also noted.

Results: Ten patients were male and 11 were female. The mean age was 54.7±14.9 years. The mean follow-up was 46.4±19.1 months. The mean best health status score of the EQ-5D (EQ-VAS) was 73.9±16.5. Tibiotalar (TT) fusion occurred in all patients, while ST fusion was not achieved in ten patients. Four of these patients underwent secondary procedures, while no intervention was planned for the other six patients because they were asymptomatic.

Conclusions: This study has demonstrated that unresected subtalar articular cartilage leads to a significant rate of ST fusion failure. Nevertheless, the possibility of partial fusion or fibrous fusion at the reaming site is thought to be the reason for the high rate of asymptomatic patients.

Key Words: Tibiotalocalcaneal, arthrodesis, intramedullary nailing, osteoarthritis, subtalar joint resection

ÖZ

Amaç: Bu çalışmanın amacı, subtalar (ST) eklemde kıkırdak rezeksiyonu yapılmadan intramedüller çivileme (İMÇ) ile tibiotalokalkaneal artrodezin (TTKA) klinik ve fonksiyonel sonuçlarını değerlendirmektir.

Yöntemler: Ocak 2013- Aralık 2022 tarihleri arasında kliniğimizde ST eklemin kıkırdak rezeksiyonu yapılmaksızın İMÇ ile TTKA gerçekleştirilen 21 hastanın 22 ayak bileği (bir hasta bilateral) retrospektif olarak incelendi. Hastaların demografik ve klinik özellikleri, etiyolojileri, Kellgren-Lawrence sınıflandırması, ameliyat sonrası kaynama oranı, füzyon durumu ve komplikasyonları kaydedildi. Avrupa Yaşam Kalitesi 5 Boyut (EQ-5D) skorları da not edildi.

Bulgular: Hastaların 10'u erkek, 11'i kadın olup, ortalama yaşı 54.7±14.9 yıl idi. Ortalama takip süresi 46.4±19.1 ay idi. EQ-5D'de en iyi sağlık skoru ortalaması 73.9±16.5 idi. Hastaların tümünde tibiotalar (TT) füzyon görülürken, on hastada ST füzyon elde edilemedi. Bu hastaların dördünde sekonder prosedürler uygulanırken, diğer altı hastada asemptomatik olması sebebiyle girişim planlanmadı.

Sonuç: Bu çalışma subtalar eklem kıkırdağının rezeke edilmemesinin ciddi oranda ST füzyon başarısızlığına neden olduğunu göstermiştir. Buna rağmen, hastaların yüksek oranda asemptomatik olmalarının nedeni olarak, oyma bölgesindeki kısmi füzyon ya da fibröz füzyon olasılığı düşünülmektedir.

Anahtar Kelimeler: Tibiotalokalkaneal, artrodez, intramedüller çivileme, osteoartrit, subtalar eklem rezeksiyonu

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INTRODUCTION

Tibiotalocalcaneal arthrodesis (TTCA) was first described by Lexer [1] in 1906 and the first case of TTCA with a metal intramedullary nail (IMN) into the ankle was reported by Adams [2] in 1948. It is an effective salvage procedure for severe deformity and instability of the hindfoot and ankle. It is usually indicated in failed ankle fusion, failed total ankle arthroplasty, and cases of severe bone loss due to conditions such as Charcot's disease , rheumatoid arthritis, severe post-traumatic osteoarthritis, and tuberculosis arthroplasty [3-7]. The main goal of arthrodesis is to relieve pain, correct deformity, and achieve a plantigrade, stable foot [8]. TTCA with IMN is advantageous in terms of alignment, length, and stability [7,8]. In addition, this procedure requires less soft tissue dissection and offers early mobilization with full weight-bearing [9,10].

Preparation and stabilisation of both joints are essential steps in TTCA surgery. Although open surgical cartilage resection is used to prepare the joint, soft tissue problems remain the main challenge. Therefore, alternative percutaneous and arthroscopic procedures have been developed to reduce soft tissue problems [5,11]. TTCA without ST cartilage resection is the other alternative procedure [9,10,12,13]. In this procedure, the ST cartilage is debrided by just reaming. TTCA with or without cartilage resection of the ST joint has advantages and disadvantages. However, TTCA with cartilage resection of both the ankle and the ST joint is in terms of superior due to its rapid and high fusion rate. Furthermore, stabilising the ST joint can reduce deformity and increase stability in patients with neuropathic arthropathy, severe deformity, and severe post-traumatic osteoarthritis. However, ankle cartilage resection alone with TTCA is superior in terms of shorter operative time and less soft tissue injury [9].

Cartilage resection of the ST joint is critical in TTCA, but additional open surgical procedures may lead to more soft tissue problems and longer surgical time [9]. Especially considering that most patients with indications for TTCA have an increased risk of infection and soft tissue problems, it may be a crucial challenge for these patients. Limited studies in the literature use TTCA without cartilage resection of the ST joint [9,12,13]. The arthrodesis mechanism is based on the reamerisation, and it was put forward complete or incomplete fusion is obtained with this technique. However, studies have shown optimistic results that do not adequately reflect potential complications [9,12,13]. Therefore, further literature is needed to determine the necessity of subtalar joint cartilage resection. The current study has asked about the clinical outcomes and complications associated with tibiotalocalcaneal arthrodesis using intramedullary nails unresected subtalar cartilage and how these outcomes compare to traditional subtalar cartilage resection techniques.

MATERIALS AND METHODS

Study design and study population

This single-center, retrospective study was conducted at a tertiary care hospital's Department of Orthopedics and Traumatology between January 2013 and December 2022. Patients who underwent TTCA with IMN in our clinic were analyzed. Those who underwent TTCA with unresected ST cartilage and were followed for more than 1 year were included. Surgery was indicated for various reasons in 21 patients, including post-traumatic arthropathy (13 patients), neuropathic arthropathy (five ankles of four patients), rheumatoid arthritis (one patient), primary osteoarthritis (one patient), failed total ankle arthroplasty (one patient), and failed TTCA (one patient). Patients who were lost to follow-up and resected ST joint cartilage were excluded. Finally, a total of 22 ankles of 21 patients were enrolled. One patient was bilateral. Preoperative Kellgren-Lawrence osteoarthritis grades were grade 3 in four patients and grade 4 in 18 patients. Data, including demographic and clinical characteristics of the patients, etiology, Kellgren-Lawrence classification, postoperative fusion rate and complications, were recorded. In addition, the European Quality of Life 5 Dimensions (EQ-5D) scores were noted. A written informed consent was obtained from each patient. The study was approved by the Institutional Ethics Committee (2021/191) and conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

All patients were prepared in the supine position and administered cefazolin 1 g intravenously and 30 minutes before tourniquet inflation. The ankle was operated using an anterior approach. The ankle joint cartilage was resected over the tibiotalar (TT) joint surface using an osteotome, while the ST joint surface was preserved. The foot was placed in the plantigrade position with 5°external rotation and 5° valgus. A plantar heel incision was made. Under fluoroscopy guidance, an intramedullary guide wire was inserted into the calcaneus, talus, and tibia. After the insertion of the IMN, the distal part of the joint was fixed with two locking screws and the proximal part was fixed with two locking screws. The wound was closed, a short leg cast was applied to all patients for the first 15 days postoperatively, and then an elastic bandage was applied.

The patients were followed at weeks 2, 6, 12 and every three months after that. During the follow-up visit, anteroposterior (AP) and lateral ankle X-rays were obtained. Both TT and ST joint fusion were evaluated on AP and lateral radiographs. Fusion was defined as trabeculation crossing the fracture at three cortices on X-rays. CT was used for suspected cases after radiographic evaluation. Delayed fusion is defined as fusion that occurs later than 6 months postoperatively, although no or incomplete fusion is observed on a CT scan within 6 months postoperatively. Successful arthrodesis was defined as the lack of pain on palpation and weight-bearing during clinical examination.

Statistical analysis

Descriptive data were expressed as mean ± standard deviation (SD), median (min-max) for continuous variables, and number and frequency for categorical variables. As the group's sample size was less than 50, the Shapiro-Wilk test was used to check for normality. The Mann-Whitney U test was used when the data did not follow a normal distribution, and the Student t-test was used to analyse the difference between the measurements of the two groups. P values less than 0.05 were considered statistically significant.

RESULTS

Of the 21 patients, 10 were male, and 11 were female. The mean age was 54.7±14.9 (range, 18 to 78) years, and the mean body mass index (BMI) was 28.2±3.1 kg/m2. Six patients (27%) were smokers. The indications for surgery were as follows: post-traumatic arthropathy (13 patients), neuropathic arthropathy (five ankles of four patients), rheumatoid arthritis (one patient), primary osteoarthritis (one patient), failed total ankle arthroplasty (one patient) and failed TTCA (one patient). A synthetic graft was used in 14 cases, while a synthetic graft combined with an autograft was used in eight cases for the ankle joint. The baseline demographic and clinical characteristics of the patients, Kellgren-Lawrence classification, postoperative fusion rates, fusion status, and complications are shown in Table 1.

Table 1- Descriptive data of the patients

		n:21
Age, mean±SD (min-max)		54.7±14.9 (18.0-78.0)
Sex, n(%)	Female	11(52.4)
	Male	10(47.6)
BMI, mean±SD (min-max)		28.2±3.1 (20.0-33.3)
		n:22
Side, n(%)	Right	12(54.5)
	Left	10(45.5)
Follow-up, mean±SD (min-max)		46.4±19.1 (12.0-86.0)
Etiology, n(%)	Post-traumatic	13 (59.1)
	Neuropatic	5 (22.7)
	OA	1 (4.5)
	RA	1 (4.5)
	Failed TAA	1 (4.5)
	Failed TTCA	1 (4.5)
Fusion rate, n(%)	TT	22 (100.0)
	ST	12 (54.5)
Fusion Time (week), mean±SD (min-max)	TT (n:22)	18.4±5.5 (12.0-30.0)
	ST (n:12)	25.7±8.3 (16.0-40.0)
Kellgren Lawrence	Stage 3	4(18.2)
	Stage 4	18(81.8)

SD: Standart deviation, BMI: Body mass index, min: minimum, max: maximum, TTCA: Tibiotalocalcaneal arthrodesis; TT: Tibiotalar; ST: Subtalar; RA: Rheumatoid Arthritis; OA: Osteoarthritis; TAA: Total Ankle Arthroplasty, TTCA: Tibiotalocalcaneal arthrodesis.

The mean follow-up was 46.4±19.1 (range, 12 to 86) months. The mean EQ-5D score was 0.82±0.17. The mean best health status score (EQ-VAS) was

73.9±16.5. The means of EQ-5D subscales were: mobility 1.72±0.63, self-care 1.54±0.80, usual activities 1.59±0.73, pain/discomfort 1.50±0.59, anxiety/depression1.27±0.45 and EQ-5D Index 0.82±0.17. In addition, TT fusion was achieved in all patients (100%), and ST fusion was in 12 patients (54.5%). Six delayed ST fusions occurred. The mean time for TT and ST fusion was 18.4±5.5 weeks and 25.7±8.3 weeks, respectively.

Four patients have no complication. There were six delayed ST fusions. Spontaneous delayed fusion occurred between 30 and 40 weeks in three of them, one of them spontaneously fused after the screw breakage (Case#17). However, the other three required secondary procedures for fusion. One patient received antibiotics for a superficial infection (Case#3). The other had a deep infection. After the patient was treated with nail removal and antibiotic treatment, fusion was obtained at 36 weeks (Case#12-L). The last delayed fusion occurred at 32 weeks after dynamization (Case#7). In ten of the cases, a lack of ST fusions was observed. There was no difference in the EQ-5D score based on ST fusion status (Table 2). Four of them experienced hardware failure, including three cases of intramedullary nail (IMN) failure and one case of screw breakage. Additionally, three patients developed deep infections. Six of the patients with ST nonfusion were observed because they were asymptomatic (Table 3). Two cases of nail irritation were occurred and implants were removed. Additionally, three implants (Cases 4,12,16) were removed due to deep infection and one implant (Case#1) was removed due to nail breakage (Table 3). Although the left side of case 12 underwent spontaneous fusion following treatment of the infection, the other two patients with deep infection required one further surgery for subtalar arthrodesis, but this was declined (Cases 4 and 16). One of the three IMN breakages was observed because the patient was asymptomatic (Case#8). The hardware was removed in the other two patients. However, only one of the patients underwent revision surgery with screws (Case#12-R), as the other patient declined the additional intervention for subtalar arthrodesis (Case#1) (Table 3).

DISCUSSION

In the present study, we evaluated clinical and functional outcomes of TTCA unresected ST joint cartilage. The results of the current study showed that all patients achieved TT fusion, while a high rate of failed ST fusion was observed. Although the rate of failed ST fusion is high, secondary surgical interventions were required less frequently than expected because the majority of patients were asymptomatic.

Table 2- Comparison of EQ-5D outcomes according to ST fusion status

	ST Fusion (+) (n:10)	ST Fusion (-) (n:12)	p
Mobility	1.66±0.65	1.80±0.63	0.604[1]
Self-Care	1.50±0.80	1.60±0.84	0.758[1]
Usual Activities	1.50±0.67	1.70±0.82	0.581[1]
Pain/ Discomfort	1.50±0.67	1.50±0.52	0.851[1]
Anxiety/ Depression	1.17±0.39	1.40±0.51	0.232[1]
EQ-5D Index	0.82 ±0.15	0.78±.0.17	0.586[2]
EQ-VAS	75.8 ±16.7	71.0 ±13.7	0.546[1]

1 Independent T-test, 2 Mann-Whitney U Test
ST: Subtalar, EQ-5D: European Quality of Life 5 Dimensions (EQ-5D) score, VAS: Visual Analogue Scale

External fixators, IMNs, plates, and cannulated screws are usually used for fixation during TTCA. The main advantage of external fixators is that they can be used in case of chronic osteomyelitis and bone defects. However, the main disadvantages include prolonged duration of treatment, pin tract infection, and being painful and uncomfortable for the patient. In addition, nonfusion or malfusion can be seen in the osteotomy site in the tibia in patients undergoing bone transport [14]. Cannulated screws can be utilized, particularly in patients without neuropathy and bone defect, although these screws are biomechanically less effective than other tools [14]. Plates can be combined with grafts in case of bone defects and to provide augmentation in patients with a previous history of IMN. However, this method is associated with soft tissue injury and fibulectomy, requiring larger soft tissue dissection. Several studies comparing plates and IMN have concluded that both methods are similar biomechanically, although plates seem to provide more stable fixation [14]. Also, IMN can be used in patients with neuropathic arthropathy and severe deformity [14]. Previous studies have

Table 3- Summary of cases who performed TTCA.

Case #	Age	Sex	Side	BMİ	Etiology	TT Fusion (week)	ST Fusion (week)	Complication	Treatment of Complications	Follow-up (month)
1	18	F	L	25	Post-traumatic	16	-	IMN Breakage	Implant Removal	37
2	51	F	L	29	Post-traumatic	20	-	ST nonfusion	Observation	69
3	42	M	R	28	Post-traumatic	20	40	Superficial Infection and Delayed Fusion	Antibiotic treatment	44
4	62	M	R	27	Neuropathic	28	-	Deep Infection	Implant Removal + Spacer	33
5	52	F	R	28	Neuropathic	12	-	ST nonfusion	Observation	54
6	38	F	R	33	Post-traumatic	17	24	-	-	60
7	56	F	R	20	Post-traumatic	16	32	Delayed Fusion	Dynamisation	57
8	58	F	L	32	RA	20	-	IMN Breakage	Observation	58
9	55	F	L	29	OA	12	16	Irritation	Implant removal	48
10	56	F	R	29	Post-traumatic	16	-	ST nonfusion	Observation	49
11	54	M	L	33	Post-traumatic	12	-	ST nonfusion	Observation	46
12	24	F	R	27	Neuropathic	20	-	IMN Breakage	Revision arthrodesis with screw	86
	24	F	L	27	Neuropathic	12	36	Deep Infection Delayed Fusion	Implant Removal	74
13	57	M	R	30	Neuropathic	12	20	-	-	26
14	66	F	R	33	Failed TAA	20	20	Irritation	Implant Removal	55
15	74	F	L	29	Failed TTCA	24	30	Delayed Fusion	Observation	30
16	78	M	L	27	Post-traumatic	30	-	Deep Infection	Implant Removal + Spacer	36
17	68	M	R	28	Post-traumatic	26	34	Screw Breakage Delayed Fusion	Observation	57
18	48	M	L	28	Post-traumatic	16	20	-	-	55
19	60	M	L	27	Post-traumatic	20	36	Delayed Fusion	Observation	12
20	60	M	R	27	Post-traumatic	12	16	-	-	13
21	72	M	R	25	Post-traumatic	24	-	ST nonfusion	Observation	21

TTCA: Tibiotalocalcaneal arthrodesis; TT: Tibiotalar; ST: Subtalar; F: Female; M: Male; RA: Rheumatoid Arthritis; OA: Osteoarthritis; TAA: Total Ankle Arthroplasty, TTCA: Tibiotalocalcaneal arthrodesis, IMN:

shown that IMN is associated with less nonfusion than other methods [15]. The main advantage of IMN is that it does not require wide soft tissue resection.

Figure 1. A: Anteroposterior and lateral X-ray images of post-traumatic ankle osteoarthritis. B: Anteroposterior and lateral X-ray images at postoperative 24 months.

The main goal of any fixation method is to achieve sufficient compression and alignment. Research has shown that intramedullary nailing (IMN) is the most effective method for minimizing soft tissue damage. In conventional TTCA with IMN, the ankle and subtalar joints are removed to create a suitable environment for fusion [16-18]. This procedure is more reliable for achieving fusion as optimal bone fusion requires aligning the two cancellous bone surfaces and ensuring stability and compression. However, this method is associated with more soft tissue damage and a longer operation duration. Additionally, it may increase the risk of infection and soft tissue disorders or exacerbate pre-existing conditions. The most preferred approach for ankle arthrodesis with IMN involves preparing both the ankle and ST joint. This method is associated with

high fusion rates in both joints [11,16-18,19]. Both approaches use the same surgical method for the ankle, resulting in comparable success rates for the fusion of the TT joint. Furthermore, a study found a nonfusion rate of 13%, and nonfusion occurred in the ankle in two and the ST joint in four patients [19]. In another study, the fusion rate was 96.6%, and only one patient experienced nonfusion in the TT joint [16]. Furthermore, a study showed a fusion rate of 90%, with nonfusion occurring in the ST joint in two patients and the TT joint in one patient [17]. In this study, all patients underwent the same open procedures for the TT joint, resulting in TT fusion. Although a low rate of soft tissue problems is expected when the ST joint is not resected, four infections (three deep and one superficial) were observed at the surgical site of TT fusion.

Apart from the conventional technique, TTCA can be performed without resecting the ST joint or with partial resection. This method causes less soft tissue damage and has a shorter operation duration. However, it is important to consider the possibility of fusion developing in this site, as the ST joint is not resected. During drilling for IMN fixation, partial debridement and autografting have already occurred in the ST joint. In this respect, a similarity can be drawn with arthrodesis through the use of arthroscopic and percutaneous partial debridement. No additional arthroscopic or percutaneous procedures were performed for ST joint debridement in this study. To achieve fusion with the percutaneous technique, it is necessary to eliminate the remaining cartilage and obtain a bone repair response. Several factors can contribute to the destruction of remaining cartilage, including depletion of synovial fluid, immobilization, compression-induced cartilage destruction, and synovitis in patients with rheumatoid arthritis [20]. The arthrodesis mechanism of the unresected subtalar joint technique is based on reaming, and it has been suggested that this technique achieves complete or incomplete fusion. In cases where percutaneous arthrodesis is performed, even without radiographic evidence of bone fusion, many of these patients have reported incomplete bone fusion or fibrous fusion [21]. In the present study, the ST fusion rates are lower than in the literature (% 54.5). Although there was a high rate of nonfusion, there was little need for secondary interventon. This could be attributed to partial bone fusion or fibrous fusion in asymptomatic patients. The current study demonstrates that there was no difference in the EQ-5D score based on ST fusion status. Similarly, it has been reported that although the nonfusion rate in hallux rigidus patients undergoing percutaneous metatarsophalangeal arthrodesis was almost 20%, all patients were asymptomatic [21]. Based on a systematic literature review, it was found that nearly a quarter of nonfusion joints in minimally invasive arthrodesis of the first metatarsophalangeal joint were asymptomatic, while 5.5% were symptomatic [22].

Literature reveals a limited number of studies performing unresected ST joint cartilage, and these studies have shown results similar to those of the standard approach [9]. In a case series, Mulhern et al. [9] found a fusion rate of 91.2% at six months and 100% at nine months. Although the authors reported no rate for ST joint separately, either advanced osteoarthritis or partial fusion/stable pseudoarthrosis was seen in all patients. Only one patient underwent revision surgery using the classical approach, because the patient reported postoperative ST joint pain. Furthermore, the authors concluded that ankle arthrosis was not affected by the absence of ST joint preparation. Therefore, they suggest that TTCA can be performed without ST joint resection for all patients, as both methods resulted in similar clinical outcomes. In another study, the ankle fusion rate was 100%, whereas no fusion was observed in the ST joint for two patients. Despite these results, some authors have reported limited success and a more cautious approach [23]. Gross et al. [13] reported fusion rates of 86% for TT and 74% for ST in their study. Although the fusion rate of the TT joint seems to be compatible with previous studies, the lower fusion rate of the ST joint can be attributed to insufficient compression and the lack of ST joint resection. Therefore, the authors began performing percutaneous resection of the ST joint after completing the study. Moore et al. [12] recommended ST joint resection only for patients with preoperative movement of the ST joint.

Several studies have shown that both methods significantly improve functional and pain scores

[11, 16-18, 23]. The standard approach resulted in pain relief and improved quality of life for 79% of patients [17], while the method of unresected ST joint cartilage had a patient satisfaction rate of 92% [23]. However, both methods are associated with complications, including infection, nonfusion, and residual deformity [9, 13, 16, 17]. In a systematic review, 22% of patients who underwent the standard approach required reoperation [18]. Another study reported a reoperation rate of 30% in patients who underwent unresected ST joint cartilage surgery [13]. In our study, the mean EQ-VAS was 73.9±16.5. This study has demonstrated that unresected subtalar articular cartilage is associated with a significant rate of complications. These included 10 cases of ST nonfusion, 6 cases of delayed fusion and 2 cases of nail irritation. Four fusion-related complications were due to infection. Despite the high rate of complications, only eight of the cases required reoperation. Furthermore, there was no difference in the EQ-5D score according to ST joint fusion status. Therefore, these findings suggest that partial bony or fibrous fusion may improve functional status.

This study has several limitations. First, it is a retrospective study without information on preoperative functional status. Therefore, the improvement in patients' clinical status couldn't be compared. Lacking of a control group is another limitation. Although radiographic evidence of fusion is required for the presence of fusion, this may not be sufficient to differentiate partial fusion from complete fusion, as partial fusion can be achieved in the ST joint. However, complete fusion can be achieved [9]. The main strength of this study is its long-term follow-up; fusion was also assessed with pain.

Conclusion: In conclusion, the current study has shown that unresected subtalar articular cartilage is associated with a significant incidence of ST fusion failure, which makes us think about the results of existing studies examining unresected ST articular cartilage. The cause(s) of the lower-than-expected rate of symptomatic patients, despite the high rate of ST fusion failure, should be investigated in further studies.

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