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Original Article

Tibiocalcaneal arthrodesis for the treatment of advanced stage Charcot arthropathy: Clinical and radiological outcome analysis of patients with diabetes mellitus followed for at least 2 years

İleri evre Charcot artropatisinin tedavisi için tibiokalkaneal artrodez: Diyabetes mellituslu hastaların en az 2 yıllık takibi ile klinik ve radyolojik sonuç analizi

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Abstract

Aim: Charcot arthropathy (CA) described by Jean-Martin Charcot is a noninfectious degenerative and destructive process of the bones, joints and soft tissues in the area of the foot and ankle which associated with peripheral neuropathy. The purpose of this study was to evaluate the outcomes of tibiocalcaneal fusion using a retrograde hind foot ankle nail fixation system in 5 Charcot patients.

Material and Methods: Between 2014 and 2016, a total of 5 patients (4 women and 1 man) who underwent tibiocalcaneal arthrodesis for the treatment of advanced CA (Brodsky type 4) were evaluated. The demographic characteristics, clinical (AOFAS scores, early and late complications) and radiological (time for a union) evaluation parameters and patient satisfaction were analyzed before and after surgery.

Results: The mean preoperative AOFAS score was 64.8 ± 8.55 and mean postoperative score was 82.6 ± 12.99. The difference between preoperative AOFAS and postoperative AOFAS scores were statistically significant. During the clinical and radiological follow-up; infection, implant failure, and peri-implant fractures were checked and complications were recorded.

Conclusion: AOFAS scores were recorded before surgery after full weight bearing and it was found that talocalcaneal arthrodesis which was achieved with intramedullary nailing significantly increased AOFAS score compared to the preoperative AOFAS score.

Keywords: Charcot arthropathy; tibiocalcaneal arthrodesis; limb-salvage; nail fixation; diabetes mellitus

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Öz

Amaç: Jean-Martin Charcot tarafından tanımlanan Charcotartropatisi, periferiknöropati ile ilişkili ayak ve ayak bileği bölgesindeki kemiklerin, eklemlerin ve yumuşak dokuların enfeksiyöz olmayan dejeneratif bir hastalığıdır. Bu çalışmanın amacı, 5 Charcotartropati hastasında retrograd arka ayak bileği fiksasyon sistemi kullanılarak yapılan tibiokalkaneal füzyonun sonuçlarını değerlendirmektir.

Gereç ve Yöntemler: 2014-2016 yılları arasında ileri Charcotartropati tedavisi için tibiokalkanealartrodez uygulanan 5 hasta (4 kadın ve 1 erkek) değerlendirildi. Ameliyat öncesi ve sonrası demografik özellikler, klinik (AOFAS skorları, erken ve geç komplikasyonlar) ve radyolojik (birleşme zamanı) değerlendirme parametreleri ve hasta memnuniyeti analiz edildi.

Bulgular: Ameliyat öncesi ortalama AOFAS skoru 64.8 ± 8.55 ve ortalama ameliyat sonrası skor 82.6 ± 12.99 idi. Ameliyat öncesi AOFAS ve ameliyat sonrası AOFAS skorları arasındaki fark istatistiksel olarak anlamlı bulundu. Klinik ve radyolojik takip sırasında; enfeksiyon, implant yetmezliği ve implant çevresi kırıklar ve komplikasyonlar kaydedildi.

Sonuç: AOFAS skorları ameliyat öncesi kaydedilmiş ve intramedüller çivileme ile elde edilen talokalkanealartrodezin AOFAS skorunu preoperatif AOFAS skoruna göre anlamlı derecede artırdığı bulunmuştur.

Anahtar kelimeler: Charcot artropati; tibiokalkaneal artrodez; uzuv kurtarma; çivileme; diabetes mellitus

Introduction

Charcot arthropathy (CA) described by Jean-Martin Charcot is a noninfectious degenerative and destructive process of the bones, joints and soft tissues in the area of the foot and ankle which associated with peripheral neuropathy.[1] Estimated prevalence of CA is ranging from 0.08 % to 13%.[2] In Charcot foot, osteolysis and demineralization occurs in bones as a result of microvascular dilatation and arterio-venous shunts associated with autonomous neuropathy and extremities are exposed recurrent micro traumas due to loss of sensation as a result of neuropathy. As a result of continuing ambulation on the insensitive extremities, capsular and ligamentous injuries, fractures and joint dislocations arises on foot.[3] In literature, numerous classification systems (called Eichenholz, Broadsky, Sanders and Frykberg, Rogers Classification.) are described for the Charcot foot according to severity, localization and complexity of the disease (Figure 1)(Table 1).[4]

With the increasing prevalence of diabetes mellitus (DM) worldwide, treatment of Charcot arthropathy and its potentially limb-threatening complications in the foot and ankle is gaining importance. Treatment options include nonoperative therapies (offloading, cast applications, medical management) and surgical treatments. The goal of treatment, whether operative or nonoperative, is to achieve a plantigrade foot with osseous stability.[5] If the efforts for nonoperative treatment of unbraceble or unstable foot fails, below the knee amputation is then required. To provide limb-salvage surgery few options are available. Current surgical options to stabilize limb include pan-talar, tibiotalocalcaneal or talocalcaneal arthrodesis. Pantalar or tibiotalocalcaneal arthrodesis may not be possible in the presence of associated talar avascular necrosis, fragmentation or resorption. There is a small number of reports in the literature about tibiocalcaneal arthrodesis.[6]

The purpose of this study was to evaluate the outcomes of tibiocalcaneal fusion using a retrograde hind foot ankle nail fixation system in 5 Charcot patients with severe ankle and hindfoot deformity and total talar bone loss.

Material and Methods

Patients

Between 2014 and 2016, a total of 5 patients (4 women and 1 man) who underwent tibiocalcaneal arthrodesis for the treatment of advanced CA (Brodsky type 4) were evaluated (Figure 2,3,4,5,6). Patients who were diagnosed with Charcot-associated ankle and hindfoot deformity but had not yet developed deep (exposed deep fascia) foot or ankle ulceration, were considered candidates for tibiocalcaneal arthrodesis and included in the study cohort. The degree of ankle and hind foot instability and deformity had to be Advanced enough and associated with real or potential cutaneous compromise to be considered for tibiocalcaneal arthrodesis. Exclusion criteria included a diagnosis of ulceration deep to the deep fascia, osteomyelitis and/or peripheral arterial

disease (PAD) not amenable to revascularization. All the patients had insulin dependent type II DM at the time of surgery and having previously been given a recommendation of a below-knee amputation.

For all patients, nails were applied by the same surgeon with a retrograde approach (RCA). The institutional review board approval (KA 20/16) was obtained. The principles outlined in the Declaration of Helsinki were followed and written informed consent from all participants was obtained.

Scales

- Brodsky's classification: This classification is an anatomic-based classification system for Charcot arthropathy. It is specific to the foot and based on the most common regions affected(Table 1, Figure 1).[7]

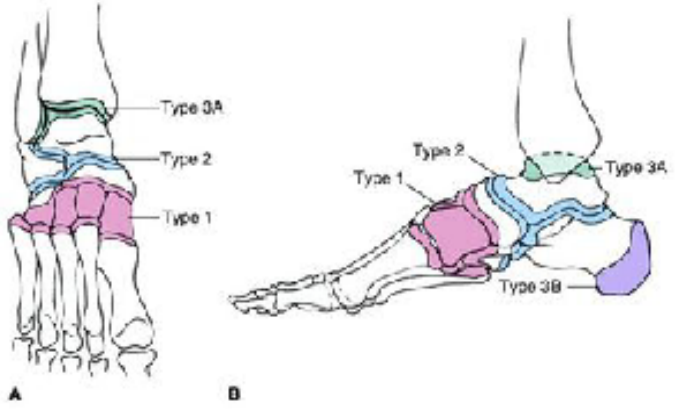

Figure 1: AP (A) and lateral (B) drawings demostrating Brodsky's anatomic classification of the Charcot foot.

Table 1: Descriptive table of the Brodsky Classification

Brodsky Classification	
Type 1	Involves tarsometatarsal and naviculocuneiform joints
Type 2	Involves subtalar, talonavicular or calcaneocuboid joints
Type 3A	Involves tibiotalar joint
Type 3B	Follows fracture of calcaneal tuberosity
Type 4	Involves a combination of areas
Type 5	Occurs solely within forefoot

- The American Foot and Ankle Score (AOFAS):This Scale combines subjective scores of pain and function provided by the patient with objective scores based on the surgeon's physical examination of the patient.[8]

- Visual AnalogueScale (VAS): This Scale was accepted in the literature and in this study it was used to evaluate the patients' pain between 0 and 10 points. When the scale score increased, the patient's pain level was considered to increase.[9]

Figure 2: Pre-operative and post-operative plain radiographs of Patient 1.

A/B: Lateral and Anterior-Posterior plain radiograph of the ankle (pre-operative)

C/D: Anterior-Posterior and Lateral plain radiograph of the ankle (post-operative)

Figure 3: Pre-operative and post-operative plain radiographs of Patient 2.

A/B: Anterior-Posterior and Lateral plain radiograph of the ankle (pre-operative)

C/D: Lateral and Anterior-Posterior plain radiograph of the ankle (post-operative)

Figure 4: Pre-operative and post-operative plain radiographs of Patient 3.

A/B: Anterior-Posterior and Lateral plain radiograph of the ankle (pre-operative)

C/D: Anterior-Posterior and Lateral plain radiograph of the ankle (post-operative)

Figure 5: Pre-operative and post-operative plain radiographs of Patient 4.

A/B: Anterior-Posterior and Lateral plain radiograph of the ankle (pre-operative)

C/D: Anterior-Posterior and Lateral plain radiograph of the ankle (post-operative)

Figure 6: Pre-operative and post-operative plain radiographs of Patient 4.

A/B: Anterior-Posterior and Oblique plain radiograph of the ankle (pre-operative)

C/D: Anterior-Posterior and Lateral plain radiograph of the ankle (post-operative)

Surgical Technique

Patients were positioned supine on the standard operating table after sterilization and coverage performed. A lateral curvilinear skin incision to the ankle joint was made. Lateral malleolus osteotomy was performed then talar bone fragments were excised. All the fibrous tissue and inflamed synovial tissues were also debrided. The articular surface of the distal tibia and calcaneus were removed with a power saw perpendicular to the weight bearing axis of the tibia. Thought the created regular shaped surfaces, the positioning of the ankle at neutral dorsiflexion, neutral to 5 degrees of valgus and similar external rotation to the contralateral extremity was obtained. The nail entry point was similar to that described previously in the literature.[6,10] A guide wire was passed to the proximal tibia and the intramedullary canal was reamed. After nail length was determined, the nail (ExpertHAN, Depuy-Synthes) was placed in the proper position. Percutaneous distal locking of the nail was achieved using the insertion/aiming guide. Proximal locking was done with a freehand technique with image intensification monitoring. After compression of the arthrodesis site was achieved, distal fibula used as a bone graft.

A below-knee splint was used for 7-10 days then weight bearing total contact cast was applied, postoperatively. Clinical and radiological evaluations of the implant status and bone union were evaluated following each month. Presence of bony union at the arthrodesis site the cast was removed and the patient then allowed limited weight bearing with a walker for 4-6 weeks. At the end of the post-operative therapy, period patient was allowed to walk freely with protective shoes.

Statistical analysis

The demographic characteristics, clinical (AOFAS scores, early and late complications) and radiological (time for a union) evaluation parameters and patient satisfaction were analyzed before and after surgery. Union of the tibiocalcaneal fusion was determined both clinically and radiographically by the lead author. Mean values and Standard deviations was used for parametric data and median ± distribution width was used for nonparametric data. Data were analyzed by using SPSS (Statistical Package for the Social Sciences) for Windows v24.0.

Results

The mean patient age was 62.2±3.49 years and the mean body weight was 78.2 ± 13.24 kilograms (range to 68-101). All the patients had DM type 2 at the time of surgery and had a Brodsky Type 4 Charcot foot. The mean duration of DM was 12±4.85 years (range 7 to 19). Of the 5 patients (4 women, 1 man) in this study, 3 patients (3 women) had also chronic renal failure. All patients had a normal distal blood supply. Patients enrolled in the study were observed for a period of 34.8 ± 10.73 (range 24 to 48) months follow-up after free walking. (Table 2, Table 3)

Table 2: Descriptive table of all patients. (DM: diabetes mellitus, VAS: visual analog scale, AOFAS: The American Foot and Ankle Score)

	Patient number				
Variable	**1**	**2**	**3**	**4**	**5**
Age (year)	58	67	64	62	60
Gender	Female	Male	Female	Female	Female
Body weight (kg)	68	70	76	101	76
Duration of DM (month)	7	19	14	8	12
Creatinine	7.23	0.81	0.59	5.82	6.58
Brodsky's grade	4	4	4	4	4
Preoperative VAS	3	4	2	3	4
Preoperative AOFAS	76	54	64	60	70
Postoperative VAS	1	4	1	1	2
Postoperative AOFAS	95	62	92	80	84
Unsupported walking	Yes	No	Yes	Yes	Yes
Duration of union (week)	17	28	12	12	12
Osteomyelitis	No	Yes	No	No	No
Complication	No	Yes	No	No	No
Postoperative Foot Ulceration	-	-	-	-	-
Implant failure	-	-	-	-	-
Peri-implant fractures	-	-	-	-	-
Postoperative follow-up (month)	24	42	48	36	24

Table 3: Descriptive table of all patients (DM: diabetes mellitus, VAS: visual analog scale, AOFAS: The American Foot and Ankle Score)

Variable	Minimum	Maximum	Mean/ Median	SD
Age	58	67	62.20*	3.49
Body weight (kilogram)	68	101	78.20*	13.24
Duration of DM (month)	7	19	12*	4,85
Creatinine	0.59	7.23	4.21*	3.24
Preoperative VAS	2	4	3	0.84
Preoperative AOFAS	54	76	64.80*	8.55
Postoperative VAS	1	4	1	1.30
Postoperative AOFAS	62	95	82.60*	12.99
Unsupported walking	1	2	2	0.45
Duration of union (week)	12	28	12	6.94
Osteomyelitis	0	1	0	0.45
Complication	0	1	0	0.45
Postoperative follow-up (month)	24	48	34.80*	10.73

(*) Mean value

The results of clinical and radiological observation are summarized in Table 3. The mean preoperative AOFAS score was 64.8 ± 8.55 and mean postoperative score was 82.6 ± 12.99. The American Foot and Ankle Score values increased postoperatively, but the Visual Analog Scale (VAS) scores did not change among the patients. The preoperative and postoperative VAS values were not different among the patients (Table 4). All patients except one patient (patient 3) could walk without support and all of the patients had painless foot and no ulcerative wound on the soles. Union was achieved in all patients in an average of 12 ± 6.94 weeks (range 12-28). During the clinical and radiological follow-up; infection, implant failure, and peri-implant fractures were checked and only "patient 2" had osteomyelitis. Patient satisfaction was excellent in 4 patients and fair in 1 patient.

Table 4: The preoperative and postoperative comparison of AOFAS and VAS scores

Variable (I/J)	t/ Z	p
Preoperative AOFAS/ Postoperative AOFAS	-8.575*	0.006
Preoperative VAS/ Postoperative VAS	-1.890	0.059

The Paired Samples t test and Wilcoxon Signed Ranks test, p<0.05 (AOFAS : The American Foot and Ankle Score, VAS: Visual Analog Scale, t: t score, Z: Z score) (*) *t* value

Discussion

In the last phase (called Broadsky type 4) of the Charcot arthropathy, surgical options are limited and like an amputation generally limb threatening. The deformity can lead to ankle instability and skin ulcers which can result in osteomyelitis with the associated risk of possible limb amputation. With the addition of total talar bone loss to the disease, the situation becomes more difficult and complicated. Schneekloth et al. systematically reviewed surgical treatment options in diabetic patients with Charcot neuropathy in the literature and 77 of the 860 cases (%8.9) were amputated.[11] However, in current literature, there has been increasing interest in surgery to avoid amputations and provide the plantigrade foot with osseous stability. Schneekloth et al. show that the most common surgical procedure is tibiotalocalcaneal arthrodesis (%19.8 of all cases) and limb salvage procedures at the end stage Charcot foot gains popularity but no information has been given about the cases of talocalcaneal arthrodesis in their studies.[11] This may be due to the fact that Charcot arthropathies with total talar bone loss are rare cases which are published in the literature as case reports or case series. Different surgical fixation techniques are used for patients with Charcot arthropathy to achieve talocalcaneal arthrodesis in the literature and the most applied technique is intramedullary nailing. Talectomy with talocalcaneal fusion using retrograde intramedullary nailing is a good salvage option for patients with Charcot arthropathy. In tibiocalcaneal fusion, it is important to achieve rigid fixation and a plantigrade foot.[12,13] In patients with Charcot arthropathy, obtaining a plantigrade and non-ulcerative foot that patients can step on without using a supportive device is one of the most important goals of the treatment table (Figure 7). However, the nail design used in this study (ExpertHAN, Depuy-Synthes) is for patients who have talus. Therefore, in patients who undergo tibiocalcaneal arthrodesis, the configuration of the screws applied through the nail may be inadequate. This can be considered in the design of new nails for ankle arthrodesis. In present study, there was no stability problem consistent with other studies using intramedullary nails, and no additional fixation method was needed to contribute to stability. As demonstrated by Caravaggi et al. it is possible to achieve this with intramedullary nails and consistent with them our study showed that all patients could walk freely using the only custom-made shoes.[14] Furthermore, study findings demonstrated that nail arthrodesis achieved total bone fusion rate and there was no need for bone grafts except distal fibula. In contrast to Abhijit et al. the average duration of a bone union in this study was shorter.[15] Good results have also been reported in patients with plate-screw fixation.[15-17] All patients had a stable, plantigrade foot and were pleased with the outcome.

Figure 7: Post-operative photographs of the patients (Published with permission from patients).

A: Patient 3 (Post-operative 6th month)

B: Patient 5 (Post-operative 12th month)

On the other hand, when studies with patients undergoing talocalcaneal arthrodesis are examined in literature, no objective scoring system used to assess functional and clinical outcomes after surgery except Abhijit et al or no statistical analysis of whether the relationship between the parameters and results are meaningful was found.[6, 13, 15-18] In present study, AOFAS scores were recorded before surgery after full weight bearing and it was found that talocalcaneal arthrodesis which was achieved with intramedullary nailing significantly increased AOFAS score compared to the preoperative AOFAS score. Additionally, no statistical relationship was observed among the DM duration, chronic renal disease and bone union time. Furthermore, probability of the unsupported walking score of the patients could be increase if this postoperative AOFAS scores would be increased. In accordance with this data, patient satisfaction was recorded excellent in 4 patients and good in 1 patient. In the studies, which include patients who had Charcot arthropathy with total talar bone loss and treated with intramedullary nailing, the most common complication is soft tissue infection. Other common complications are amputations, stress fractures, and implant failures. In our study, osteomyelitis was observed in one patient. This may be due to a limited number of patients. On the other hand, correlation analysis results showed that osteomyelitis or other complication related to the surgery could decrease the unsupported walking score of the patients, postoperatively.

The present study had some limitations. Firstly, the number of the patients included in this study was small. Therefore, power-analysis could not be performed. Secondly, the outcome of the surgical treatment was evaluated retrospectively and the postoperative follow-up period was inconsistent and ranged from 24 to 48 months. Thirdly, considering polyneuropathy associated reduction of the sensation of pain, the results of the AOFAS scores must be viewed carefully.

Conclusion

The recent increase in the number of patients with diabetes has increased the frequency of Charcot's ankle also. The deformity can lead to ankle instability and skin ulcers which can result in osteomyelitis with the associated risk of possible limb amputation. Limb salvage is an important alternative treatment modality instead of transtibial amputation. Talectomy with talocalcaneal fusion using retrograde intramedullary nailing is a good salvage option for patients with Charcot arthropathy. In tibiocalcaneal fusion, it is important to achieve rigid fixation and a plantigrade foot. Patients with a stable and plantigrade foot will be satisfied with the results.

Declaration of conflict of interest

The authors received no financial support for the research and/or authorship of this article. There is no conflict of interest.

References

1. Molines L, Darmon P, Raccah D. Charcot's foot: newest findings on its pathophysiology, diagnosis and treatment. Diabetes Metab 2010; 36: 251-5.
2. Frykberg RG, Belczyk R. Epidemiology of the Charcot foot. Clin Podiatr Med Surg 2008; 25:17-28.

3. Olivera Stojadinovic IP, Katherine A. Gordon, Marjana Tomic-Canic. Physiology and Pathophysiology of Wound Healing in Diabetes. In: Aristidis Veves JMG, Frank W. LoGerfo, editor. The Diabetic Foot Medical and Surgical Management. 1. 3 ed. Springer New York Dordrecht Heidelberg London: Springer Science+Business Media; 2012. p. 127.
4. Dalla Paola L. Confronting a dramatic situation: the charcot foot complicated by osteomyelitis. Int J Low Extrem Wounds 2014; 13: 247-62.
5. Wukich DK, Sung W. Charcot arthropathy of the foot and ankle: modern concepts and management review. J Diabetes Complications 2009; 23: 409-26.
6. Myerson MS, Alvarez RG, Lam PW. Tibiocalcaneal arthrodesis for the management of severe ankle and hindfoot deformities. Foot Ankle Int 2000; 21: 643-50.
7. Rosenbaum AJ, DiPreta JA. Classifications in brief: Eichenholtz classification of Charcot arthropathy. Clin Orthop Relat Res 2015; 473: 1168-71.
8. Van Lieshout EM, De Boer AS, Meuffels DE et al. American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score: a study protocol for the translation and validation of the Dutch language version. BMJ Open 2017; 7: 12884.
9. Boonstra AM, Schiphorst Preuper HR, Reneman MF, Posthumus JB, Stewart RE. Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. Int J Rehabil Res 2008 ;31: 165-9.
10. Moore TJ, Prince R, Pochatko D, Smith JW, Fleming S. Retrograde intramedullary nailing for ankle arthrodesis. Foot Ankle Int 1995; 16: 433-6.
11. Schneekloth BJ, Lowery NJ, Wukich DK. Charcot Neuroarthropathy in Patients With Diabetes: An Updated Systematic Review of Surgical Management. J Foot Ankle Surg 2016; 55: 586-90.
12. Caravaggi CM, Sganzaroli AB, Galenda P et al. Long-term follow-up of tibiocalcaneal arthrodesis in diabetic patients with early chronic Charcot osteoarthropathy. J Foot Ankle Surg 2012; 51: 408-11.
13. Ettinger S, Stukenborg-Colsman C, Plaass C et al. Tibiocalcaneal arthrodesis as a limb salvage procedure for complex hindfoot deformities. Arch Orthop Trauma Surg 2016; 136: 457-62.
14. Caravaggi C, Cimmino M, Caruso S, Dalla Noce S. Intramedullary compressive nail fixation for the treatment of severe Charcot deformity of the ankle and rear foot. J Foot Ankle Surg 2006; 45:20-4.
15. Abhijit R. Guha DS, Razi Zaidi, Ali Abbassian. Talectomy and Tibiocalcaneal Arthrodesis in Adult Complex Hindfoot Reconstruction. Techniques in Foot & Ankle Surgery 2013; 12: 158-62
16. Aikawa T, Watanabe K, Matsubara H, Nomura I, Tsuchiya H. Tibiocalcaneal Fusion for Charcot Ankle With Severe Talar Body Loss: Case Report and a Review of the Surgical Literature. J Foot Ankle Surg 2016; 55: 247-51.
17. Alvarez RG, Barbour TM, Perkins TD. Tibiocalcaneal arthrodesis for nonbraceable neuropathic ankle deformity. Foot Ankle Int 1994; 15:354-9.
18. LaPorta GA, Nasser EM, Mulhern JL. Tibiocalcaneal arthrodesis in the high-risk foot. J Foot Ankle Surg 2014; 53:774-86.