



Joint debridement and microfracture for treatment late-stage Freiberg-Kohler's disease: Long-term follow-up study

Antonio Viladot^{a,*}, Luca Sodano^b, Lorenzo Marcellini^c

^a Department of Orthopaedic Surgery, Tres Torres Clinic, Barcelona, Spain

^b Operative Unit of Orthopaedics and Traumatology, Aurelia Hospital, Rome, Italy

^c Operative Unit of Orthopaedics and Traumatology, Israelite Hospital, Rome, Italy

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ABSTRACT

Background: Freiberg-Kohler's disease is not a common disease and although various reports have been described since 1914, treatment methods are not completely established. The purpose of the present retrospective study was to evaluate the long-term outcomes following joint debridement and microfracture procedures for the treatment of Freiberg-Kohler's disease.

Methods: Fifteen consecutive patients (16 feet) with Freiberg-Kohler's disease (Smillie's classification grade III–V) were operated between May 1996 to December 2011. All patients followed the same post-operative protocol. The objective and subjective evaluations were taken at the initial examination and at final follow-up. **Results:** Mean follow-up was 11 years \pm 5.5 (range 4.2–19.7 years). The AOFAS score, VAS score and ROM of the MTP joint improved significantly after surgery (p value $<$ 0.05).

The AOFAS score improved from a preoperative value of 46.7 ± 15.5 points to 83.2 ± 9.4 points postoperative ($p < 0.05$). The mean preoperative joint ROM was $28^\circ \pm 8^\circ$ and $49^\circ \pm 13^\circ$ postoperative ($p < 0.05$). VAS score improved from a preoperative value of 5.5 ± 1.2 points to 1.2 ± 1 points at last follow-up ($p < 0.05$). At the end of follow-up 13 patients (81%) declared they were very satisfied, 3 patients (19%) satisfied and nobody unsatisfied.

Conclusions: Our results suggest that joint debridement and microfracture procedure is an effective surgical treatment for late-stage Freiberg-Kohler's disease with decrease of daily pain, improved ROM, and high patient satisfaction.

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1. Introduction

Although the etiology of Freiberg-Kohler's disease is controversial, most theories point to a vascular deficit of the metatarsal head associated with mechanical overload [1,2]. Smillie classified the natural history of Freiberg-Kohler's disease into five stages according to macroscopic appearance (Table 1) [3]. In the early stages of Freiberg-Kohler's disease, such as stages I, and II conservative methods should be recommended first, whereas surgical methods are usually reserved for stages III, IV, and V [4–7]. Conservative treatments consist in nonsteroidal anti-inflammatory drugs, footwear modifications, plantar orthotics for reducing metatarsal head pressure and reduction of physical activity. Surgery is indicated when conservative treatment gives no benefit. Multiple surgical procedures are available for the

treatment of Freiberg-Kohler's disease: isolated joint debridement [8] can be associated with microfracture technique [9], dorsal wedge osteotomy to change the orientation of the articular surface [10], silicone or prosthesis arthroplasty [11,12], perichondral grafting [13,14], and metatarsal head resection [15]. The purpose of this retrospective single surgeon study is to evaluate the long-term results of joint debridement and metatarsal head microfracture technique for the treatment of Freiberg-Kohler's disease. All patients treated for Freiberg-Kohler's disease during the study period were treated with the same procedure.

2. Materials and methods

This retrospective study collected 15 consecutive patients (16 feet) presenting late stage (stage III–V) of Freiberg-Kohler's disease treated with debridement and microfracture technique from May 1996 to December 2011. All patients were participants in the practice of the senior author (A.V.V.) Diagnosis was based on clinical history, physical examination and plain radiographs for

* Corresponding author.

E-mail addresses: 9393avv@gmail.com (A. Viladot), luca.sodano@hotmail.it (L. Sodano), marcellini.lor@gmail.com (L. Marcellini).

Table 1
Smillie classification for Freiberg disease.

				
Fracture through the epiphysis	Central depression	Central depression that leads to medial and lateral projections at the margins with an intact plantar hinge	Central portion frees from the intact plantar hinge, forming a loose body with associated fractures of the medial and lateral projections	Flattening of the metatarsal head with secondary degenerative changes

all patients. According to Smillie's classification system one case was in stage III, seven cases were in stage IV and eight in stage V. All clinical and radiographic evaluations were taken at the initial examination and at final follow-up. Inclusion criteria were: manifestation of persistent pain in spite of more than 6 months of conservative treatment; lacking of previous operative treatment for the same problem in the past. It is worth to note that 9 out of 16 cases were affected by other pathologies of the forefoot which disrupts the normal biomechanics of the forefoot (Table 2). All patients, appropriately informed, expressed their consent to take part in the study.

2.1. Clinical and radiographic evaluation

All clinical data and radiographs were evaluated pre-treatment and at last follow-up. The clinical examination included the non-weight-bearing, assisted MTP joint dorsal and plantar range of motion (ROM). The MTP ROM was considered normal when it was greater than 75°, moderate when ranging between 30° and 74°, and stiff below 30°. The subjective evaluation was based on the AOFAS score [16] and relief of pain was evaluated using VAS score [17]. The VAS measures the degree of pain, subjectively perceived by the patient, on a centimeter scale of 10 cm, where

0 cm corresponds to absence pain and 10 cm refers to maximum pain perceived. At the end of follow-up patients received an additional questionnaire. They were asked if they were satisfied with the results of the surgery, satisfied with reservations, or unsatisfied and if they would have the procedure again. Radiographic examinations were performed for each individual during follow-up appointments and at last follow-up with a weight-bearing foot x-ray. Morphological changes in the metatarsal head and MTP joint were evaluated.

2.2. Operative technique

All patients were operated in supine position under general anesthetic or local block and with ankle pneumatic tourniquet. A longitudinal incision over the MTP joint was executed. Capsulotomy was performed between the extensor digitorum longus and brevis tendons. Synovectomy with joint debridement was performed. Debridement involved removal of loose body, metatarsal head prominences and any periarticular osteophytic spurs. The surface of the cartilage defect was drilled with 1.1 mm Kirschner wire (K-wire) about 4–5 times until inducing bleeding. The wound was closed using simple skin stitches. The foot was wrapped in a compressive dressing.

Table 2
Demographic data.^a

Case	Age	Gender	Follow-up years	Side of surgery	Joint affected	Smillie's classification	Pre-existing conditions	Forefoot surgery
1	59	M	4.2	R	II	V	–	–
2	71	F	19.7	R	II	IV	–	–
3	65	M	14.7	L	II	V	HR	KELLER
4	67	M	16.5	R	II	V	HR	KELLER
5	28	F	12.2	R	III	IV	–	–
6	43	F	13	R	II	V	–	–
7	26	F	9.6	R	III	IV	–	–
8	55	M	7.7	L	II	III	HV	NST
9	61	F	10.3	L	II	V	–	–
10	45	F	5.9	R	II	IV	HV	NST
11	68	M	5.7	L	II	IV	HV	NST
12	50	M	12	L	II	V	HV	CHEVRON
13	60	F	4.4	L	II	IV	HV	CHEVRON
14	47	F	19	R	II	V	HV	NST
15	16	F	19.5	L	III	IV	–	–
16	44	F	9	L	III	V	HV	NST
Total 16	50.3 ± 16.2	M(5)/F(10)	11 ± 5.5	8/8	II MTP – (12 feet) III MTP – (4 feet)	III – (1); IV – (7); V – (8)	9/16	

^a M: male, F: female, L: left, R: right, HV: Hallux Valgus, HR: Hallux Rigidus, NST: non-surgical treatment.

2.3. Postoperative management

All patients were discharged from hospital in one day wearing a soft bandage and hard-soled postoperative shoe allowing for full weight-bearing walking. The patients wore the shoe for 3 weeks. Dressings were changed 1 week postoperatively and were removed after 2 weeks if the wound was healed. Patients started active-passive dorsiflexion-plantarflexion exercises of the MTP joint within the first postoperative day.

2.4. Statistical analysis

The Wilcoxon test was used to analyze statistical differences between preoperative and last follow-up AOFAS score, VAS score and ROM. For all tests, a p-value of <0.05 was considered statistically significant.

3. Results

The study included 10 women and 5 men (16 feet) with an average age of 50.3 ± 16.2 years (range, 16–71 years). The bilateral case was treated in two operative time (Fig. 1). Mean follow-up was 11 ± 5.5 years (range 4.2–19.7 years) (Table 2). For all cases, AOFAS score, VAS score and ROM of the MTP joint improved significantly after surgery (Table 3). According to the postoperative AOFAS scores 1 case obtained excellent results and 13 were classified as good and 2 as fair. The total AOFAS score improved from a preoperative value of 46.7 ± 15.5 points to 83.2 ± 9.4 points postoperative ($p < 0.05$). All

toes were clinically stable. MTP joint ROM after surgery was moderate in 13 cases and in 3 case it was stiff. The mean preoperative joint ROM was $28^\circ \pm 8^\circ$ and was $49^\circ \pm 13^\circ$ postoperative ($p < 0.05$). VAS score improved from a preoperative value of 5.5 ± 1.2 points to 1.2 ± 1 points at last follow-up ($p < 0.05$). No progression of osteonecrosis was observed in any of the examined cases at last follow-up (Fig. 2). At the end of follow-up 13 patients (81%) declared they were very satisfied, 3 patients (19%) satisfied with reserve and all patients would have the procedure again. Regarding the three patients satisfied with reserve affected by severe stiffening were successfully treated with hard soled. There were no complications regarding wound infection.

4. Discussion

Several studies hypothesize that abnormal mechanical stress and deficiency of the blood supply of the metatarsal head are the major causative factors of Freiberg-Kohler's disease [18,19]. Smillie [4] supported the idea of a traumatic cause for the Freiberg-Kohler's disease. In fact, the author noted that repeated trauma are responsible for trabecular stress injury and argued that this injury occurs more frequently in feet with first ray pathology. Abnormal mechanical stress of the lesser metatarsals may be induced by pathologies of the forefoot which disrupt the normal weight-bearing, such as hallux rigidus, hallux valgus and any malalignment of the first ray. In fact, these conditions increase the load assumed by the second metatarsal [20]. It is worth noting that 9 out of 16 cases in the analysed population presented these conditions. Furthermore,

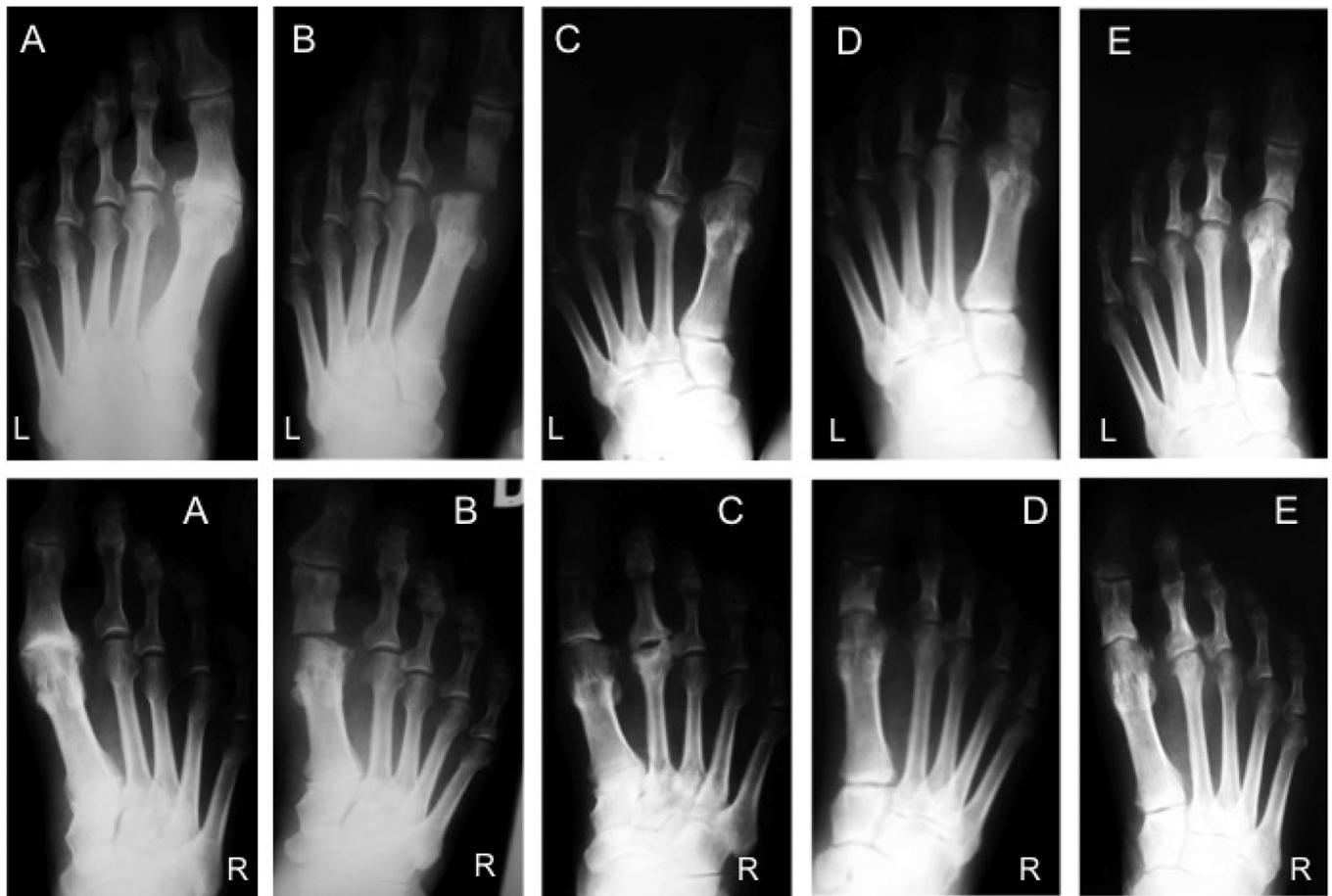


Fig. 1. Patient with bilateral Freiberg's disease. Left foot: A: Preoperative radiography with hallux rigidus, B: post-operative after Keller procedure, C: Freiberg's disease on the II metatarsal that was classified as Smillie stage V., D: 1 year of follow-up, E: last follow-up at 14.7 years. Right foot: A: Preoperative radiography with hallux rigidus, B: Post-operative after Keller procedure, C: Freiberg's disease on the II metatarsal that was classified as Smillie stage V., D: 1 year of follow-up, E: Last follow-up at 16.5 years.

Table 3
Clinical evaluation.^a

Case	JOINT ROM		VAS score		AOFAS score							
	(In degree)				Pain		Function		Alignment		Total score	
	PRE	LFU	PRE	LFU	PRE	LFU	PRE	LFU	PRE	LFU	PRE	LFU
1	15	25	8	3	0	30	15	27	8	8	23	65
2	25	50	5	1	20	30	19	35	15	15	54	80
3	25	50	7	2	0	30	20	35	15	15	35	80
4	35	55	5	2	0	30	25	40	15	15	40	85
5	35	60	5	1	20	30	25	37	15	15	60	82
6	40	50	5	0	20	40	25	35	15	15	60	90
7	35	55	5	0	20	40	29	37	15	15	64	92
8	35	65	4	0	20	40	29	35	15	15	64	90
9	20	25	7	2	0	30	25	35	15	15	40	80
10	30	55	4	0	20	40	25	35	8	15	53	90
11	25	50	5	1	20	40	20	30	15	15	55	85
12	20	45	5	1	20	40	24	35	8	15	52	90
13	35	65	4	0	20	40	29	40	15	15	64	95
14	25	50	6	2	0	30	20	37	8	15	28	82
15	30	55	6	1	0	30	25	40	15	15	40	85
16	15	25	7	3	0	30	15	22	0	8	15	60
Mean	28	49	5.5	1.2	11.2	34.4	23.1	34.7	12.3	14.1	46.7	83.2
S.D.	±8	±13	±1.2	±1	±10.2	±5.1	±4.5	±4.8	±4.5	±2.4	±15.5	±9.4
P value	<0.05		<0.05		<0.05		<0.05		<0.05		<0.05	

^a VAS: visual analogue scale, AOFAS: American Orthopaedic Foot and Ankle Society lesser metatarsophalangeal-interphalangeal scale, ROM: range of motion, PRE: preoperative, LFU: last follow-up, SD: standard deviation.



Fig. 2. A 47-year-old woman with Freiberg's disease that was classified as Smillie stage V. A: Preoperative radiography, B: Postoperative radiograph at 1 month demonstrating more anatomical articular joint surface, C: Radiograph at 19 years of follow-up showed the joint space still preserved and signs of remodeling.

key roles in the abnormal stress concentration are played by the metatarsal length and mobility. The longer length of second metatarsal with respect to the first predisposes the former to sustain greater stresses during normal gait [21]. The results of Stanley et al. confirm the relevant role of second metatarsal length, as they observed that the second metatarsal was the longest in 94% of 33 patients with unilateral Freiberg-Kohler's disease [1]. Furthermore, the second metatarsal is the least mobile, thereby conferring the

greatest stress at that metatarsal head distally. We rated that 12 (75%) out of 16 cases presented Freiberg-Kohler's disease on the second metatarsal head. This percentage is in agreement with other studies that found Freiberg-Kohler's disease in second metatarsal head from 68% to 85.7% of patients [22,23] Obviously, the abnormal stress conditions influence the vascular supply. The metatarsal head itself is supplied by small vessels that penetrate the sides of the insertion of the joint capsule [24,25]. Compression of these vessels from a joint

effusion, swelling and shoes with the narrow tip and high heels, may compromise the blood flow [26]. Several surgical Freiberg-Kohler's disease treatment methods have been proposed, but there is no general agreed consensus on the optimal operative procedure [7]. Metatarsal dorsal wedge osteotomies are widely used treatment methods for the Freiberg-Kohler's disease for which several authors reported good results [27,28]. Although these procedures are simple, they pose several disadvantages: lesser toe transfer metatarsalgia, floating toe phenomenon, and problems related with fix methods. Kilic et al. [23] treated 6 patients with cheilectomy and microfracture procedure and 8 patients with dorsal crescentic osteotomy and they concluded that there are not significant differences between dorsiflexion osteotomy and joint debridement with microfracture procedure in term of improvement in pain relief and ROM of the MTP joint. Other treatments include silicone or hemiarthroplasty for which the published researches do not provide sufficient evidence of effectiveness. Addition of a cartilage autograft is an experimental technique that seems to lead to good short-term results with improvement in the AOFAS score after 1 year in the advanced stages of the disease, but longer term follow-up is still needed [13]. Resection of the metatarsal head is not recommended because of the high risk of break in alignment of the metatarsal arch, deformity of the toes, transfer metatarsalgia, and gait disturbance [15]. In the present study, we analysed the long term results of Freiberg-Kohler's disease treated with joint debridement and microfracture technique. Debridement procedure was originally proposed by Freiberg [29]; recently Erdil showed that treatment of Freiberg-Kohler's disease with debridement provided a significant improvement of AOFAS score and better quality of life for his patients [30]. We decided to couple the debridement with microfracture technique using K-wire to aid the restoration of the cartilage defects and also encourage metatarsal morphology remodeling. The results of this study are in agreement with these obtained by Pastides et al. [9] which treated 11 patients with late stage of Freiberg-Kohler's disease using debridement and microfracture procedure. They obtained a significant reduction of pain at 6 months, with 2.1 and 3.1 of VAS score at rest and on mobilizing, respectively ($p < 0.05$). Our long-term results showed that debridement with microfracture is an effective surgical treatment for late stage Freiberg-Kohler's disease with significant improvement in pain relief, AOFAS, ROM of the MTP joint and patient satisfaction. Debridement coupled with microfracture procedure provides two main advantages over the other methods since it involves a single operative procedure, without the need of hardware removal, and it does not cause metatarsal shortening or other anatomic abnormalities. There are several limitations associated with our case series. The most important limitation is that this study is retrospective and does not compare the results of this technique with the others. Another limitation is the small number of patients. In our view, additional prospective and comparative studies are needed to evaluate optimal treatment method. In view of the collected results, we can conclude that joint debridement and microfractures is an effective, simple and safe procedure for the treatment of late stage Freiberg-Kohler's disease. No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work.

Conflict of interest

The authors, their immediate families, and any research foundations with which they are affiliated have not received

financial payments or other benefits from any commercial entity related to the subject of this article.

References

- [1] Stanley D, Betts RP, Rowley DI, Smith TW. Assessment of etiologic factors in the development of Freiberg's disease. *J Foot Surg* 1990;29:444–7.
- [2] Bayliss NC, Klenerman L. Avascular necrosis of lesser metatarsal heads following fore foot surgery. *Foot Ankle* 1989;10:124–8.
- [3] Smillie IS. Freiberg's infraction (Kohler's second disease). *J Bone Joint Surg Br* 1957;39(3):580.
- [4] Smillie IS. Treatment of Freiberg's infraction. *Proc R Soc Med* 1967;60:29–31.
- [5] Sproul J, Klaaren H, Mannarino F. Surgical treatment of Freiberg's infraction in athletes. *Am J Sports Med* 1993;21:381–4.
- [6] Sansone V, Morandi A, Dupplicato P, Ungaro E. Treatment of late-stage Freiberg's disease using a temporary metal interpositional device. *J Bone Joint Surg Br* 2010;92:807–10.
- [7] Cerrato RA. Freiberg's disease. *Foot Ankle Clin* 2011;16(December (4)):647–58. doi:<http://dx.doi.org/10.1016/j.fcl.2011.08.008> Epub 2011 Oct 15. Review. PubMed PMID: 22118235.
- [8] Helal B, Gibb P. Freiberg's disease: a suggested pattern of management. *Foot Ankle* 1987;8:94–9.
- [9] Pastides PS, El-Sallakh S, Charalambides C. Debridement and microfracture in the treatment of Freiberg disease. *Tech Foot Ankle Surg* 2012;11(3):150–4.
- [10] Lee SK, Chung MS, Baek GH, Oh JH, Lee YH, Gong HS. Treatment of Freiberg disease with intra-articular dorsal wedge osteotomy and absorbable pin fixation. *Foot Ankle Int* 2007;28:43–8.
- [11] Shih AT, Quint RF, Armstrong DG, Nixon BP. Treatment of Freiberg's infraction with the titanium hemi-implant. *J Am Podiatr Med Assoc* 2004;4:9590–3.
- [12] Cracchiolo A, Kitaoka HB, Leventon EO. Silicone implant arthroplasty for second metatarsophalangeal joint disorders with and without hallux valgus. *Foot Ankle Int* 1988;9:10–8.
- [13] Miyamoto W, Takao M, Uchio Y, Kono T, Ochi M. Late-stage Freiberg disease treated by osteochondral plug transplantation: a case series. *Foot Ankle Int* 2008;29(9):950–5.
- [14] Tsuda E, Ishibashi Y, Yamamoto Y, Maeda S, Kimura Y, Sato H. Osteochondral autograft transplantation for advanced stage Freiberg disease in adolescent athletes: a report of 3 cases and surgical procedures. *Am J Sports Med* 2011;39(11):2470–5.
- [15] Hoskinson J. Freiberg's disease: a review of the long-term results. *Proc R Soc Med* 1974;67(2):106–7.
- [16] Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int* 1994;15(7):349–53.
- [17] Huskisson EC. Measurement of pain. *Lancet* 1974;2(7889):1127–31.
- [18] Trott AW. Developmental disorders. In: Jahss MH, editor. *Disorders of the foot*. Philadelphia: WB Saunders; 1982. p. 207–10.
- [19] Mandell GA, Harcke HT. Scintigraphic manifestations of infraction of the second metatarsal (Freiberg's disease). *J Nucl Med* 1987;28(February (2)):249–51 PubMed PMID: 3806228.
- [20] McMaster MJ. The pathogenesis of hallux rigidus. *J Bone Joint Surg Br* 1978;60:82–7.
- [21] Donahue SW, Sharkey NA. Strains in the metatarsals during stance phase of gait implications for stress fractures. *J Bone Joint Surg Am* 1999;81:1236–44.
- [22] Gauthier G, Elbaz R. Freiberg's infraction: a subchondral bone fatigue fracture. A new surgical treatment. *Clin Orthop Relat Res* 1979;93:93–5.
- [23] Kilic A, Cepni KS, Aybar A, Polat H, May C, Parmaksizoglu AS. A comparative study between two different surgical techniques in the treatment of late-stage Freiberg's disease. *Foot Ankle Surg* 2013;19(December (4)):234–8. doi:<http://dx.doi.org/10.1016/j.fas.2013.06.004> Epub 2013 Jul 19. PubMed PMID: 24095230.
- [24] Beito SB, Lavery LA. Freiberg's disease and dislocation of the second metatarsophalangeal joint: etiology and treatment. *Clin Podiatr Med Surg* 1990;7(October (4)):619–31 Review. PubMed PMID: 2253168.
- [25] Viladot A, Viladot A. Osteochondroses: aseptic necrosis of the foot. In: Jahss M, editor. *Disorders of the foot and ankle*. 2nd ed. Philadelphia: Saunders; 1991. p. 617–38.
- [26] Carmont MR, Rees RJ, Blundell CM. Current concepts review: Freiberg's disease. *Foot Ankle Int* 2009;30:167–76.
- [27] Kinnard P, Lirette R. Freiberg's disease and dorsiflexion osteotomy. *J Bone Joint Surg Br* 1991;73(5):864–5.
- [28] Lee SK, Chung MS, Baek GH, Oh JH, Lee YH, Gong HS. Treatment of Freiberg disease with intra-articular dorsal wedge osteotomy and absorbable pin fixation. *Foot Ankle Int* 2007;28(1):43–8.
- [29] Freiberg AH. The diagnosis and treatment of common painful conditions of the foot. *Instr Course Lect* 1957;14:238–47.
- [30] Erdil M, Imren Y, Bilsel K, Erzincanli A, Bülbül M, Tuncay I. Joint debridement and metatarsal remodeling in Freiberg's infraction. *J Am Podiatr Med Assoc* 2013;103(May–June (3)):185–90 PubMed PMID: 23697722.