Knee Surg Sports Traumatol Arthrosc (2015) 23:2384–2389
DOI 10.1007/s00167-013-2784-5

ANKLE

Clinical outcomes of platelet rich plasma (PRP) as an adjunct to microfracture surgery in osteochondral lesions of the talus

Ahmet Guney · Mustafa Akar · Ibrahim Karaman · Mithat Oner · Betul Guney

Received: 12 March 2013 / Accepted: 17 November 2013 / Published online: 30 November 2013

Abstract
Purpose To compare the effect of arthroscopic microfracture surgery alone or in combination with platelet rich plasma (PRP) on functional outcomes in osteochondral lesions of the talus.
Methods A total of 35 patients were included in the study. Control subjects ($n = 16$) received treatment with microfracture surgery alone, while the remaining patients (PRP group, $n = 19$) were also given PRP. After an average follow-up of 16.2 months (range 12–24 months), patients were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) scoring system, Foot and Ankle Ability Measure (FAAM), and the visual analogue scale (VAS) for pain.
Results At baseline, AOFAS and FAAM scores were similar in the two groups, whereas pain scores (VAS) were higher in those who were assigned to combined treatment. Despite the latter finding, the combined treatment with PRP resulted in better outcomes in terms of functional scores [AOFAS, 89.2 ± 3.9 vs. 71.0 ± 10.2, ($p = 0.001$); FAAM overall pain domain, 1.0 (1.0–2.0) vs. 2.5 (1.0–4.0), ($p = 0.04$); FAAM 15-min walking domain, 1.0 (1.0–2.0) vs. 2.0 (1.0–4.0) ($p = 0.001$)]; and pain-related scores [VAS, 2.2 ± 0.8 vs. 3.8 ± 1.2, ($p = 0.001$)] as compared to arthroscopic microfracture surgery alone.
Conclusions PRP as an adjunct to arthroscopic microfracture surgery for the treatment of osteochondral lesions of the talus resulted in improved functional score status in the medium-term. Further studies to determine the long-term efficacy of this approach were warranted.
Level of evidence II.

Keywords Osteochondral lesions of talus · Platelet rich plasma · Clinical outcome · Functional outcome · Arthroscopy · Microfracture

Introduction

Osteochondral lesions of the talus result from the detachment of articular cartilage fragments with or without subchondral bone [1]. Although its aetiology is unclear, acute trauma is certainly a pre-disposing factor [3] in addition to repeating microtrauma, certain vascular conditions, infection, alignment disorders, hormonal disturbances, exposure to high atmospheric pressure, genetic factors, ossification disorders, and idiopathic causes [30]. Studies suggest a lower success rate for the conservative treatment in comparison with surgery [5, 13]. In chronic osteochondral lesions of the talus, if symptoms persist despite 6 months of the conservative treatment, surgery should be considered [6, 11]. Avoidance from appropriate surgery may result in worsening in the stage of the lesion and chronic ankle pain. Until now, no therapeutic modality has shown clear superiority over others, and indications for specific techniques

A. Guney · I. Karaman · M. Oner
Department of Orthopedics and Traumatology, Erciyes University Medical Faculty, Kayseri, Turkey

A. Guney (✉)
Department of Orthopedics, Erciyes University Gevher Nesibe Hospital, Talas yolu 5. km, 38039 Kayseri, Turkey
e-mail: dr.aguney@gmail.com

M. Akar
Department of Orthopedics and Traumatology, Osmancik State Hospital, Corum, Turkey

B. Guney
Department of Radiodiagnostics, Kayseri Research and Training Hospital, Kayseri, Turkey

are not well defined for osteochondral lesions of the talus with chronic course [15]. Current first-line recommendation comprises arthroscopic excision, debridement, and bone marrow stimulation (microfracture). This approach offers a quick healing, high success rate, low morbidity, and cost advantage [34]. However, the most appropriate surgery for specific lesions is still largely undetermined [11, 16, 31].

In recent years, growth factors (GF) in platelets are being more frequently used than isolated specific GF in different fields of medicine such as general surgery, plastic surgery, and dentistry [29, 33]. Additionally, several reports examined its effects in orthopaedic conditions, including tendon healing, diabetic wound healing, repair of bony defects, and bone extension surgery, with varying results [9, 19, 21]. Platelet rich plasma (PRP) and bone marrow aspirate concentrate have been shown to improve cartilage regeneration. It works with their array of bioactive factors and GF stored within the platelet's alpha granules [32]. Despite previous reports on the effect of PRP in a number of different conditions, no studies exist that have assessed its role in osteochondral lesions of the talus following arthroscopic microfracture surgery.

This study was undertaken to evaluate the role of PRP administration in the ankle following arthroscopic microfracture surgery in order to compare the effect of microfracture surgery alone or in combination with PRP on functional clinical outcomes. The hypothesis that combination of PRP and arthroscopic microfracture surgery would result in better functional outcomes when compared to arthroscopic microfracture surgery alone has been tested in this study.

Materials and methods

Patients attending to the outpatient facility of the Department of Orthopedics and Traumatology, Medical School of Erciyes University, with ankle pain and diagnosed as having osteochondral lesions of the talus between June 2008 and July 2010 were included in the study. A total of 35 patients (15 males, 19 females) were included. Average age was 42.8 ± 14.7 years (range 21–67) in the control group (arthroscopic microfracture surgery alone), while it was 38.5 ± 12.7 (range 18–63) in the combination treatment group (or PRP group, which received arthroscopic microfracture surgery plus PRP). Patients below 18 or over 67 years of age, pregnant women, subjects with end-stage degenerative osteoarthritis of the ankle, subjects with a lesion diameter greater than 20 mm, and those with septic arthritis sequelae were excluded.

A detailed medical history was taken, and physical examination was performed in every patient. Antero-posterior, lateral, and mortise (at 15°–20° internal rotation) radiographs were obtained in patients with symptoms such as pain in the anterior and/or posterior joint line on deep palpation or physical exertion, swelling, limited range of motion, crepitation, giving away in the ankle, and difficulty in climbing the stairs. A computerized tomography and/or magnetic resonance imaging (MRI) study was performed if surgery was planned. MRI findings were used to classify patients using the classification systems proposed by Hepple et al. [17]. No patients had previously received any treatments for osteochondral lesions of the talus.

Within the context of a randomized, prospectively designed study, two groups of participants were defined on the basis of the random numbers assigned by an automated check-in system at the time of initial visit, such that those with an even number were assigned to the combination treatment group, and those with an odd number to the control group. Those in the control group were treated with arthroscopic microfracture surgery alone, while the combination treatment group also received PRP administration in the ankle following arthroscopic microfracture surgery.

Creation of microfractures, PRP harvesting and administration

Microfractures were created arthroscopically. Caution was exercised to avoid superficial peroneal nerve injury. After removal of the osteochondral fragment, necrotic soft tissues and granulation tissues, microfractures 4-mm deep and 4-mm apart and perpendicular to the subchondral bone, were created using microfracture awls with varying tip angles (30°, 45°, and 90°). Fat particles were observed to come out of the perforations. PRP harvesting was performed on the first post-operative day using a Smart-PReP®2 system (Harvest Autologous Hemobiologics, Norwell, MA). For optimal use of PRP, a 5.4–fold (±1.2) increase on average was achieved with a mean platelet count of 1,335,500 ± 276,500 platelets/μL. All samples had a pH below 7.35. Thus, 10 % $NaHCO_3$ was added into the harvested PRP, with a resultant pH value between 7.35 and 7.55. PRP was administered through the site of portal entry, 6–24 h after the operation, immediately after the removal of hemovac drain.

Post-operative care

A short-leg vitraten mold was prepared pre-operatively for all patients in the prosthetics and orthotics unit of our department. After the termination of surgery, elastic bandage and short-leg mold were used for 3 weeks. On the first two post-operative days, ice was applied; on post-operative Day 7, passive ankle movements were initiated; at post-operative weeks 4–6, patients started partial weight-bearing

Table 1 Clinical and baseline characteristics

Parameter	Control group $n = 16$	PRP group $N = 19$	p-value
Age, year	42.8 ± 14.7	38.5 ± 12.7	n.s
Male gender, n (%)	9 (56.3 %)	7 (36.8 %)	n.s
Duration of symptoms, months	37.7 ± 36.4	18.8 ± 20.2	n.s
History of trauma, n (%)	13 (81.3 %)	13 (68.4 %)	0.46
Lesion on the right side, n (%)	7 (43.8 %)	11 (57.9 %)	n.s
Lesion medial to tallus, n (%)	13 (81.3 %)	12 (63.2 %)	n.s
BMI (mean ± SD)	27.1 ± 3.1	27.8 ± 2.1	n.s
Stage[a]			
Stage II	3 (18.8 %)	7 (36.8 %)	n.s
Stage III	10 (62.5 %)	7 (36.8 %)	
Stage IV	2 (12.5 %)	5 (26.4 %)	
Stage V	1 (6.2 %)	0	
Baseline measurements (pre-operative)			
AOFAS	46.8 ± 9.8	42.5 ± 10.3	n.s
VAS	7.3 ± 0.7	8.0 ± 0.7	**0.014**
FAAM (overall pain level)[b]	4.0 (3.0–5.0)	3.0 (2.0–5.0)	n.s
FAAM (15 min walking)[b]	3.5 (3.0–5.0)	4.0 (2.0–5.0)	n.s
FAAM (running function)[b]	5.0 (4.0–5.0)	5.0 (3.0–5.0)	n.s

Unless otherwise stated, data are presented as mean ± SD

Bold value indicates statistical significance ($p < 0.05$)

[a] According to Hepple staging based on pre-operative MRI findings

[b] Median (range)

with crutches as well as strengthening exercises; at weeks 6–8, full weight-bearing together with balance and proprioception exercises was performed; between months 4 and 6, plain running at low speed and between months 6 and 8, more intense physical activity and/or sportive activities were returned. Patients were followed for 16.2 months (range 12–24 months) on average.

Data acquisition

As a reliable, standardized, and objective assessment for the management ankle and foot disorders, American Orthopaedic Foot and Ankle Society (AOFAS) scoring system was used; also, Foot and Ankle Ability Measure (FAAM) test designed for patients with musculoskeletal conditions of the legs and ankles was administered to evaluate the treatment effects [20, 23]. Pain was measured using 10-point visual analogue scale (VAS). Measurements were performed at least 12 months after the procedure.

The study protocol was approved by local ethics committee of Erciyes University Faculty of Medicine (dated February 8, 2008, approval no. 16), and the study was conducted in accordance with the Declaration of Helsinki. All patients gave informed consent prior to study entry.

Statistical analysis

SPSS version 15.0 was used for statistical analyses of data. GPower software was used for sample size estimation. A sample size of 42 individuals in total (21 per arm) is proposed. This would give 80 % power to detect an effect size of 0.8 (one-tail) between groups for continuous outcome variables of the study. Normality was tested using Kolmogorov–Smirnov test. Intra-group and inter-group comparisons of normally distributed continuous variables were performed using paired-samples t test and independent-samples t test, respectively. Wilcoxon rank test and Mann–Whitney U test were used for intra- and inter-group comparisons of continuous variables without normal distribution, respectively. Categorical variables were compared using Chi-square test. When comparing the groups with regard to clinical outcomes (AOFAS, FAAM, and VAS scores), the null hypothesis was the absence of a difference in the mean scores. A p-value <0.05 was considered an indication of statistical significance.

Results

Clinical and baseline characteristics of the patients are shown in Table 1. Groups did not differ with regard to age, gender distribution, duration of symptoms, aetiology, lesion localization, and lateralization, BMI or disease stage. Similarly, AOFAS scores and FAAM scores of three domains were similar among the groups at baseline. However, PRP group had significantly higher VAS scores (i.e. more pain) at baseline, compared to controls [8.0 ± 0.7 vs. 7.3 ± 0.7, ($p = 0.014$)]. Post-operatively, temporary neuropraxis occurred in one case in the lateral dorsal branch of the superficial peroneal nerve that recovered spontaneously.

Table 2 Follow-up measurements

Parameter	Control group $n = 16$	PRP group $N = 19$	p-value
AOFAS	71.0 ± 10.2	89.2 ± 3.9	0.001
VAS	3.8 ± 1.2	2.2 ± 0.8	0.001
FAAM (overall pain level)[a]	2.5 (1.0-4.0)	1.0 (1.0–2.0)	0.04
FAAM (15 min walking)[a]	2.0 (1.0–4.0)	1.0 (1.0–2.0)	0.001
FAAM (running function)[a]	3.0 (2.0–5.0)	3.0 (1.0–4.0)	n.s

Unless otherwise stated, data are presented as mean ± SD

[a] Median (range)

Outcome measurements

AOFAS and VAS scores

At the follow-up, a significant improvement in AOFAS score was observed in both groups compared to baseline. However, PRP group had better AOFAS scores at follow-up than in controls (Table 2). The change in AOFAS score from baseline was 24.2 ± 7.3 versus 46.7 ± 9.7 in the control and PRP groups, respectively ($p < 0.001$).

Although both groups had a significant improvement in VAS scores at the follow-up compared to baseline, the improvement in the PRP group was more prominent as compared to controls (Table 2) despite higher pain scores at baseline (Table 1). The change in VAS scores from baseline was −3.5 ± 1.2 versus −5.7 ± 1.0 in control and PRP subjects, respectively ($p < 0.001$).

FAAM Scores

At the follow-up, both groups showed significant improvements in each domain of FAAM, i.e. overall pain level, 15-min walking distance, and running function ($p = 0.001$ for all comparisons with baseline). At the follow-up, PRP group did better on overall pain level ($p = 0.04$) and 15-min walking distance ($p = 0.001$) domains, as compared to controls (Table 2). However, outcomes of the groups were similar in terms of running function (n.s) (Table 2).

Discussion

The most important finding of the present study was the improved post-operative functional recovery of osteochondral lesions of the talus in association with PRP administration as an adjunct to microfracture surgery, when compared to microfracture surgery alone. The role of PRP in the treatment of osteochondral lesions of the talus as an adjunct to microfracture surgery has never been tested before.

Current first-line surgical treatment recommended for lesions up to 15 mm in diameter consists of arthroscopic excision together with debridement (curettage) and bone marrow stimulation (microfracture formation) [34]. Nevertheless, Jung et al. [18] suggest that arthroscopic microfracture is an acceptable treatment for cystic type of osteochondral lesions irrespective of lesion type. For this reason, subjects with lesions diameter greater than 20 mm were excluded in this study. The advantages of arthroscopic microfracture surgery include quick healing, high success rate, and low morbidity, in addition to cost-effectiveness [34].

A PubMed search involving the past 10-year period with the keywords “platelet” and “healing” has yielded approximately 1,630 publications; this observation can be considered as an indication for the recent popularity of the treatments involving the use of platelets. Currently, rather than the use of isolated GF, those already present in platelets are more frequently used. Eppley et al.’s study showed a parallel increase in the concentration of GF together with increasing platelet concentration [12]. The same principle was exploited in this study to stimulate several processes, including chemotaxis, cell proliferation, angiogenesis, extracellular matrix formation, and remodelling with the GF in platelets [14]. In a 2007 report, despite affirming most of the other effects, Rozman and Bolta [28] proposed that GF could not play an effective role during remodelling period due to the fact that remodelling starts at week 26 and that GF do not remain active for so long. In contrast, we believe that this approach still holds a potential to show a favourable impact on remodelling by triggering a cascade of events following the initial phase of trauma that last for many weeks.

Thus, due to the release of these autologous bioactive proteins (GF), both a faster and better tissue healing is achieved. PRP is also used in other fields of medicine such as general surgery, plastic surgery, and dentistry. [29, 33]. Other uses include tendon healing, diabetic wound healing, repair of bony defects, and bone extension surgery [19, 21]. Several studies used PRP in ankle and/or foot conditions with favourable results with respect to fracture healing and bone union [4, 8]. In the study by Patel et al., intra-articular PRP injection was used in knee osteoarthritis patients with degenerative cartilage lesions, and Western Ontario McMaster Osteoarthritis Index (WOMAC) scores were assessed [27]. Mei-Dan et al. [25] treated osteochondral lesions of talus with either intra-articular injection hyaluronate or PRP, and they found significantly better results with PRP.

Currently, there is no standard method for PRP harvesting. In different studies, manual methods using laboratory centrifuge devices with different parameters or a variety of other commercial platelet concentration systems have been used for this purpose. In a study by Oprea et al. [26], autologous complete blood count samples from healthy volunteers were subjected to a two-stage centrifugation (2,000 rpm for 5 min then followed by 2,000 rpm for 20 min) with a 3.5 increase in platelet count. Again in the same study, commercial platelet concentration devices achieved a sevenfold increase in platelet counts. Preparation of sterile PRP poses some challenges with manual methods. Thus, a commercial platelet concentration system was preferred for this study in order to avoid the complication of septic arthritis. Some literature data suggest that higher platelet concentrations, i.e. more effective bioactive growth factor harvesting, can be achieved with SmartPReP®2 (Harvest Autologous Hemobiologics, Norwell, MA) or Platelet Concentration Collection (PCC System, 3i Implant Innovations, Palm Beach Gardens, FL) devices. [24]. In this study, the former of the two, i.e. SmartPReP®2 was used; this device is also a FDA-approved one.

Subchondral bone loss has been reported in chronic cases with delayed diagnosis (>12 months) partly due to the nature of osteochondral lesions of the talus. Researchers studying microfracture surgery have not considered this as a contraindication to microfracture surgery [7]. In the present study, the average time to diagnosis was 28.3 months (2–120), and since most of the cases had a chronic presentation, lesion types were similar to that described in the literature.

AOFAS scores in control patients receiving microfracture surgery alone were generally in line with previous reports; however, the distribution of the scores demonstrated a wide variation in the previous studies. Despite general agreement with literature data, some differences also have been noted. For instance, in the study by Lee et al. [22], the mean pre- and post-operative AOFAS scores were 63 and 90, respectively, while the corresponding figures were 46 and 71 in the present study. The same figures in the studies by Chuckpaiwong [7] and Apprich et al. [2] were 41 and 68, and 44 and 76. The wide variation observed in scores may be partly explained on the basis of the difference in pre-operative scores. Doral et al. [10] administered hyalurane intra-articularly following microfracture surgery in patients with osteochondral lesions of the talus and observed statistically significant increases in AOFAS scores both in patients who received the injection and in those who did not. These findings support the observations of this study and show the benefits of microfracture surgery in this group of patients.

Administration of PRP after arthroscopic surgery seems to be a promising option for patients with osteochondral lesions of the talus. It is convenient since it can be administered on the first post-operative day without necessitating additional admission, and no anaesthesia is required since patient does not experience pain sensation at that early post-operative period. Risk of complications in particular infection may be an issue, although no infection was observed in this series. However, it is of note to emphasize that provision of aseptic conditions is important, as it is the case in all such post-operative interventions. The procedure actually incurs some additional cost, which seems to be outweighed by its long-term benefits in terms of functional recovery.

The limitations of this study include inadequate rehabilitation in some patients due to busy practice conditions in our clinic, relatively short follow-up, and absence of microscopic information on the effects of PRP on the quality of repair tissue and on the formation of hyaline cartilage. Proposed sample size of the study could not be reached owing to the low number of admissions, which can be regarded as a limitation. However, statistical significance could be achieved in most of the comparisons; therefore, a type II error is unlikely. In addition, the study was neither placebo-controlled nor blinded. All the study procedures were conducted by the operating team, so blindness was not technically appropriate; and given the potential risks of post-operative saline injection without a treatment purpose, study design did not include a placebo control.

Conclusions

As an adjunct to arthroscopic microfracture surgery aimed at osteochondral healing, PRP seems to offer the possibility of better functional recovery, which may result in psychological, physical, and economical benefits. Harvesting and administration of PRP is relatively easy and inexpensive, so this method can be implemented in the daily practice, without compromising routine post-operative care of the patients. However, the long-term benefits should be tested in further studies.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Alexander AH, Lichtman DM (1980) Surgical treatment of transchondral talar-dome fractures (osteochondritis dissecans). Long-term follow-up. J Bone Joint Surg Am 62:646–652
2. Apprich S, Trattnig S, Welsch GH, Noebauer-Huhmann IM, Sokolowski M, Hirschfeld C, Stelzeneder D, Domayer S (2012) Assessment of articular cartilage repair tissue after matrix-associated autologous chondrocyte transplantation or the

microfracture technique in the ankle joint using diffusion-weighted imaging at 3 Tesla. Osteoarthr Cartil 20:703–711
3. Berndt AL, Harty M (1959) Transchondral fractures (osteochondritis dissecans) of the talus. J Bone Joint Surg Am 41-A:988–1020
4. Bibbo C, Bono CM, Lin SS (2005) Union rates using autologous platelet concentrate alone and with bone graft in high-risk foot and ankle surgery patients. J Surg Orthop Adv 14:17–22
5. Canale ST, Belding RH (1980) Osteochondral lesions of the talus. J Bone Joint Surg Am 62:97–102
6. Chodos MD, Schon LC (2006) Osteochondral lesions of the talus: current treatment modalities and future possibilities. Curr Opin Orthop 17:111–116
7. Chuckpaiwong B, Berkson EM, Theodore GH (2008) Microfracture for osteochondral lesions of the ankle: outcome analysis and outcome predictors of 105 cases. Arthroscopy 24:106–112
8. Coetzee JC, Pomeroy GC, Watts JD, Barrow C (2005) The use of autologous concentrated growth factors to promote syndesmosis fusion in the Agility total ankle replacement. A preliminary study. Foot Ankle Int 26:840–846
9. de Vos RJ, Weir A, van Schie HT, Bierma-Zeinstra SM, Verhaar JA, Weinans H, Tol JL (2010) Platelet-rich plasma injection for chronic Achilles tendinopathy: a randomized controlled trial. JAMA 303:144–149
10. Doral MN, Bilge O, Batmaz G, Donmez G, Turhan E, Demirel M, Atay OA, Uzumcugil A, Atesok K, Kaya D (2012) Treatment of osteochondral lesions of the talus with microfracture technique and postoperative hyaluronan injection. Knee Surg Sports Traumatol Arthrosc 20:1398–1403
11. Easley ME (2003) Osteochondral lesions of the talus: diagnosis and treatment. Curr Opin Orthop 14:69–73
12. Eppley BL, Woodell JE, Higgins J (2004) Platelet quantification and growth factor analysis from platelet-rich plasma: implications for wound healing. Plast Reconstr Surg 114:1502–1508
13. Flick AB, Gould N (1985) Osteochondritis dissecans of the talus (transchondral fractures of the talus): review of the literature and new surgical approach for medial dome lesions. Foot Ankle 5:165–185
14. Garg AK (2000) The use of platelet-rich plasma to enhance the success of bone grafts around dental implants. Dent Implantol Update 11:17–21
15. Giannini S, Buda R, Faldini C, Vannini F, Bevoni R, Grandi G, Grigolo B, Berti L (2005) Surgical treatment of osteochondral lesions of the talus in young active patients. J Bone Joint Surg Am 87(Suppl 2):28–41
16. Hangody L, Fules P (2003) Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. J Bone Joint Surg Am 85-A(Suppl 2):25–32
17. Hepple S, Winson IG, Glew D (1999) Osteochondral lesions of the talus: a revised classification. Foot Ankle Int 20:789–793
18. Jung HG, Carag JA, Park JY, Kim TH, Moon SG (2011) Role of arthroscopic microfracture for cystic type osteochondral lesions of the talus with radiographic enhanced MRI support. Knee Surg Sports Traumatol Arthrosc 19:858–862
19. Kajikawa Y, Morihara T, Sakamoto H, Matsuda K, Oshima Y, Yoshida A, Nagae M, Arai Y, Kawata M, Kubo T (2008) Platelet-rich plasma enhances the initial mobilization of circulation-derived cells for tendon healing. J Cell Physiol 215:837–845
20. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M (1994) Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 15:349–353
21. Kitoh H, Kitakoji T, Tsuchiya H, Katoh M, Ishiguro N (2007) Distraction osteogenesis of the lower extremity in patients with achondroplasia/hypochondroplasia treated with transplantation of culture-expanded bone marrow cells and platelet-rich plasma. J Pediatr Orthop 27:629–634
22. Lee KB, Bai LB, Chung JY, Seon JK (2010) Arthroscopic microfracture for osteochondral lesions of the talus. Knee Surg Sports Traumatol Arthrosc 18:247–253
23. Martin RL, Irrgang JJ, Burdett RG, Conti SF, Van Swearingen JM (2005) Evidence of validity for the foot and ankle ability measure (FAAM). Foot Ankle Int 26:968–983
24. Marx RE (2004) Platelet-rich plasma: evidence to support its use. J Oral Maxillofac Surg 62:489–496
25. Mei-Dan O, Carmont MR, Laver L, Mann G, Maffulli N, Nyska M (2012) Platelet-rich plasma or hyaluronate in the management of osteochondral lesions of the talus. Am J Sports Med 40: 534–541
26. Oprea WE, Karp JM, Hosseini MM, Davies JE (2003) Effect of platelet releasate on bone cell migration and recruitment in vitro. J Craniofac Surg 14:292–300
27. Patel S, Dhillon MS, Aggarwal S, Marwaha N, Jain A (2013) Treatment with platelet-rich plasma is more effective than placebo for knee osteoarthritis: a prospective, double-blind, randomized trial. Am J Sports Med 41:356–364
28. Rozman P, Bolta Z (2007) Use of platelet growth factors in treating wounds and soft-tissue injuries. Acta Dermatovenerol Alp Panonica Adriat 16:156–165
29. Sammartino G, Tia M, Gentile E, Marenzi G, Claudio PP (2009) Platelet-rich plasma and resorbable membrane for prevention of periodontal defects after deeply impacted lower third molar extraction. J Oral Maxillofac Surg 67:2369–2373
30. Schachter AK, Chen AL, Reddy PD, Tejwani NC (2005) Osteochondral lesions of the talus. J Am Acad Orthop Surg 13:152–158
31. Scranton PE Jr (2004) Osteochondral lesions of the talus: autograft and allograft replacement. Tech Foot Ankle Surg 3:25–39
32. Smyth NA, Murawski CD, Haleem AM, Hannon CP, Savage-Elliott I, Kennedy JG (2012) Establishing proof of concept: platelet-rich plasma and bone marrow aspirate concentrate may improve cartilage repair following surgical treatment for osteochondral lesions of the talus. World J Orthop 3:101–108
33. Yol S, Tekin A, Yilmaz H, Kucukkartallar T, Esen H, Caglayan O, Tatkan Y (2008) Effects of platelet rich plasma on colonic anastomosis. J Surg Res 146:190–194
34. Zengerink M, Struijs PA, Tol JL, van Dijk CN (2010) Treatment of osteochondral lesions of the talus: a systematic review. Knee Surg Sports Traumatol Arthrosc 18:238–246