REVIEW ARTICLE

Sports Med 2012; 42 (10): 857-870
0112-1642/12/0010-0857/$49.95/0

Rehabilitation and Return-to-Sports Activity after Debridement and Bone Marrow Stimulation of Osteochondral Talar Defects

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Abstract

An osteochondral defect (OD) is a lesion involving the articular cartilage and the underlying subchondral bone. ODs of the talus can severely impact on the quality of life of patients, who are usually young and athletic. The primary treatment for ODs that are too small for fixation, consists of arthroscopic debridement and bone marrow stimulation. This article delineates levels of activity, determines times for return to activity and reviews the factors that affect rehabilitation after arthroscopic debridement and bone marrow stimulation of a talar OD. Articles for review were obtained from a search of the MEDLINE database up to January 2012 using the search headings 'osteochondral defects', 'bone marrow stimulation', 'sports/activity', 'rehabilitation', various other related factors and 'talus'. English-, Dutch- and German-language studies were evaluated.The review revealed that there is no consensus in the existing literature about rehabilitation times or return-to-sports activity times, after treatment with bone marrow stimulation of ODs in the talus. Furthermore, scant research has been conducted on these issues. The literature also showed that potential factors that aid rehabilitation could include youth, lower body mass index, smaller OD size, mobilization and treatment with growth factors, platelet-rich plasma, biphosphonates, hyaluronic acid and pulse electromagnetic fields. However, most studies have been conducted *in vitro* or on animals. We propose a scheme, whereby return-to-sports activity is divided into four phases of increasing intensity: walking, jogging, return to non-contact sports (running without swerving) and return to contact sports (running with swerving and collision). We also recommend that research, conducted on actual sportsmen, of recovery times after treatment of talar ODs is warranted.

1. Introduction

An osteochondral defect (OD) is a lesion involving the articular cartilage and underlying subchondral bone.[1] Many synonyms are used, such as osteochondritis dissecans,[2] transchondral fracture,[3] flake fracture,[4] talar dome fracture,[5] osteochondral fracture[6] and osteochondral lesion.[7] An OD is often not recognized and is therefore inadequately treated. This oversight is usually because of evidence from previous trauma(s) that degrade the interpretation of plain radiographs.[8] ODs can heal or remain asymptomatic, or progress to deep ankle pain on weight-bearing. The primary treatment for ODs up to 15 mm consists of arthroscopic debridement and bone marrow stimulation with an overall expected success rate of 85%.[9] The final results can take up to 1 year.[9]

ODs of the talus can severely impact quality of life, especially in high-level athletes[10,11] who are unable to train or compete as a result. For athletes with an OD, the lapse before resuming high-impact sport (after surgery) can be as much as 3–6 months.[12-14]

This article delineates levels of activity, determines times for return to activity and reviews the factors that affect rehabilitation after arthroscopic debridement and bone marrow stimulation of a talar OD.

2. Tissue Healing after Debridement and Bone Marrow Stimulation

Treatment techniques of ODs have been widely published for both non-surgical and surgical options.[9] The primary treatment for most ODs is debridement and bone marrow stimulation, with the objective of removing all unstable cartilage and underlying necrotic bone, opening and curetting cysts (figure 1) and then performing bone marrow stimulation. Bone marrow stimulation performed with a microfracture probe has the theoretical advantage that it results in multiple fractures in the trabeculae instead of destruction of the bone (figure 2). Interosseous blood vessels are also disrupted by this technique, which leads to the release of growth factors and to the formation of a fibrin clot. This clot becomes a fibrovascular repair tissue, which in turn causes the release of growth factors and cytokines to stimulate further repair including transforming growth-factor (TGF)-β, platelet-derived growth factor (PDGF), bone morphogenic proteins (BMP) and insulin-like growth factors (IGFs) to create granulation tissue.[15,16] Within 2 weeks, undifferentiated mesenchymal cells have proliferated and differentiated into osteoblast-like cells and into chondrocyte-like cells. The osteoblasts form new woven bone, whilst the chondroblasts produce a matrix containing type II collagen and proteoglycans forming fibrocartilaginous tissue within 6–8 weeks.[17-19] After 8 weeks, hyaline-like cartilage can be detected with a high component of type II collagen[17] and, at 12 weeks, the ODs are completely filled with mostly hyaline-like tissue.[19] Initially, the new subchondral bone is woven, then eventually it becomes lamellated with the subchondral region, modified to a compact bone plate and reformed tide mark. The restored bone is, however, of lesser quality than normal bone and it is not identical to the original.[20] When examined at 24 and 48 weeks, no difference in histological analysis of the cartilage is detectable.[21] At 1 year, the chondral repair tissue is a mixture of fibrocartilage and hyaline cartilage, with a considerable component of type I collagen[22] (table I).

If repair or remodelling fails to restore the functional balance of articular cartilage and subchondral bone, it can lead to a disturbed balance and a disordered joint will remain.[20]

3. Activity Levels

Before return to activity or return to sport can be considered, it is important to quantify the levels of activity. Changes in a patient's activity level can be monitored in various ways. The Tegner score is an activity-level rating that was originally developed for knee-ligament (anterior cruciate ligament) injuries but is also used for other pathologies. It

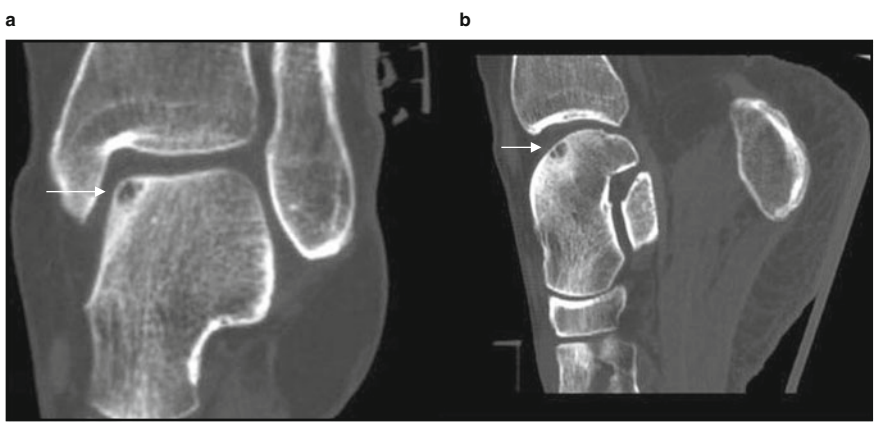

Fig. 1. CT of a patient with persisting deep pain in the ankle, showing a cyst on the medial side of the talus. (**a**) Coronal CT; (**b**) sagital CT.

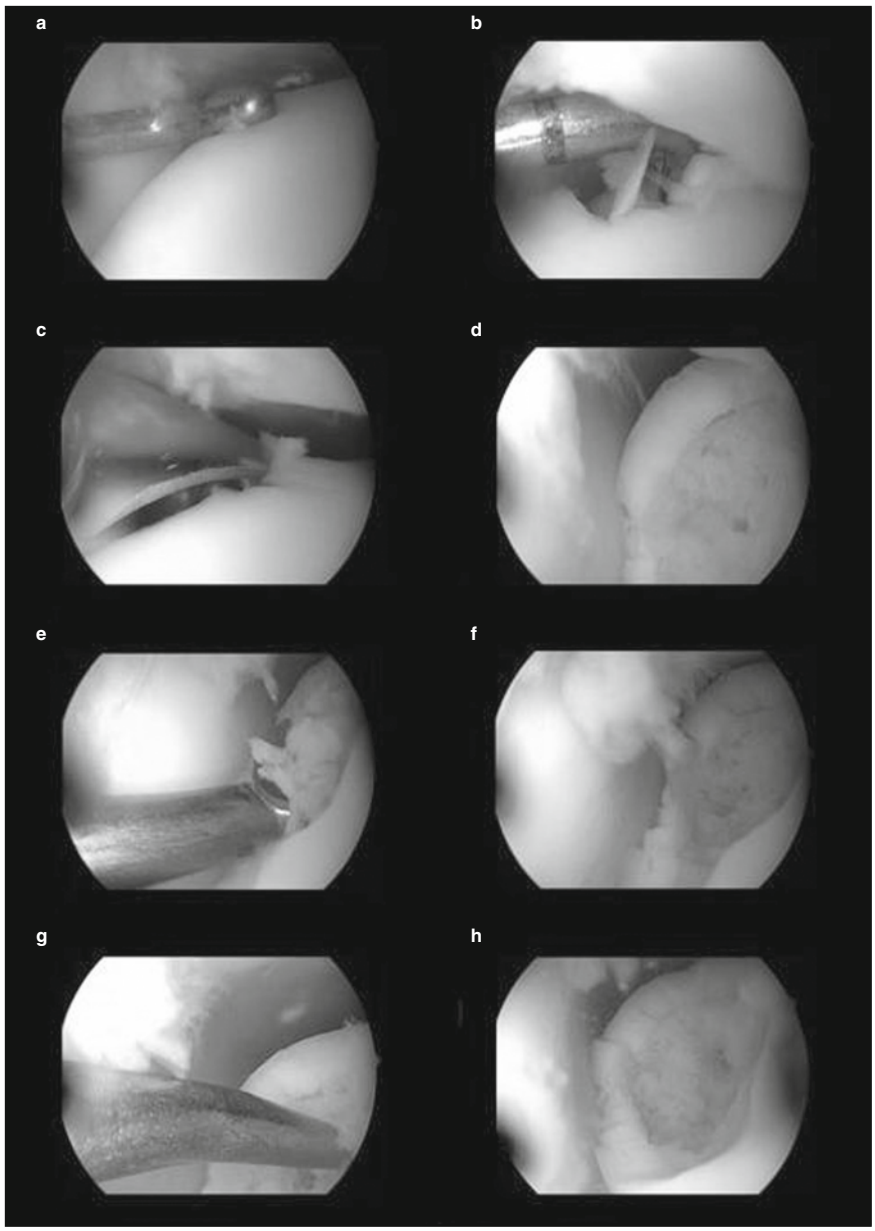

Fig. 2. Arthroscopic treatment of OD defect with debridement and bone marrow stimulation. (**a**) and (**b**) Identifying OD in talus with probe; (**c**) debridement of OD with shaver; (**d**) OD after debridement with shaver; (**e**) opening cyst in subchondral bone with curette; (**f**) OD after opening cyst in subchondral bone; (**g**) bone marrow stimulation of OD with microfracture probe; and (**h**) OD after treatment of debridement and bone marrow stimulation. **OD** = osteochondral talar defect.

is graded from 0 to 10 and covers activities in daily life, as well as recreational and competitive sports.[23]

Because knee loading is not the same as ankle loading, Halasi et al. developed an activity score designed specifically for ankle joints.[24] With 53

sports, 3 working activities and 4 general activities, and 3 levels within each group, it is a comprehensive scale. Both these methods provide specific scores with a high grade of differentiation.

Another activity score was developed in 1972 by Roles and Maudsley.[25] This simpler system is based on four classifications: excellent (no pain, full movement and full activity), good (occasional discomfort, full movement and full activity), fair (some discomfort after prolonged activity) and poor (pain limiting activities). This system measures activity level, and also pain and range of motion (ROM), and is not restricted to the ankle joint.

A more practical activity-level score was described for rehabilitation after Achilles tendon ruptures.[26] This consists of four levels of activity: walking, running, non-contact sports and contact sports. The first and most basic level of activity after an injury is to return to normal walking. The second level is to return to running, the third is to return to a non-contact sport and the highest is to return to a contact sport. This system can cover the rehabilitation of any ankle injury and can also be used to monitor the rehabilitation after surgery for talar ODs.

4. Time for Return to Activity after Debridement and Bone Marrow Stimulation

4.1 Methodology

4.1.1 Data Sources and Searches

Articles for review were obtained from a search of the MEDLINE database up to January 2012. English-, Dutch- and German-language studies were evaluated and the search headings 'osteochondral defects', 'bone marrow stimulation', 'sports/activity', 'rehabilitation', various other related factors and 'talus' were used along with the following keywords: 'articular injuries', 'osteochondral defects', 'osteochondral lesions', 'cartilage defects', 'osteochondritis dissecans', 'transchondral fracture', 'flake fracture', 'talar dome fracture', 'osteochondral fracture', 'osteochondral lesion', 'osteocartilaginous lesions and debridement', 'microfractur*', 'drilling', 'bone marrow stimulation and ankle', 'talus', 'talar', 'sports' and 'activity or rehabilitation'.

4.1.2 Study Selection

Articles were screened by their title and abstract by one observer (ICMvE), and then checked by a second observer (MLR). After selection, full-text articles were read for further screening. Selection criteria were randomized controlled trials or clinical trials in which the return to sport or to activity was studied after arthroscopic debridement and bone marrow stimulation of the talar OD. The results were analysed according to the four activity levels, as proposed by van Sterkenburg et al.[26]

5. Results

5.1 Level 1 (Walking)

The return to normal weightbearing and walking varies from immediately to 8 weeks after surgery.[14,27-31] Ogilvie-Harris and Sarrosa[31] allowed immediate full weightbearing according to comfort, whereas Chuckpaiwong et al.[27] splinted their patients for 1–2 weeks, after which they commenced ROM exercises and full weightbearing in walking boots. Saxena and Eakin[14] prevented weightbearing, using a below-knee cast boot for up to 6 weeks, although patients with

Table I. Phases of osteochondral defects healing

Phase			Time
1	Inflammatory phase	Formation of fibrin clot that releases growth factors and cytokines to format granulation tissue	Weeks 1 and 2
2	Remodelling phase	Mesenchymal cells proliferate and differentiate into chondrocyte-like cells producing a matrix containing type II collagen and proteoglycans. Formation of fibrocartilaginous tissue and bone	Weeks 3–8
		Fibrocartilaginous tissue turns into hyaline-like cartilage Formation of woven bone	Weeks 8–12
		Mixture of fibrocartilage and hyaline cartilage Formation of bone plate and reformed tide mark with restored subchondral bone	Weeks 12–48

small lesions (<3 mm in diameter) were allowed to partially bear weight after 3 weeks. All patients were allowed passive ROM exercises at 3 weeks and, at 6 weeks, active ROM exercises were allowed. In the study of Guo et al.,[28] patients were allowed to advance to full weightbearing 8 weeks after surgery, while Lee et al.[29] had a non-weightbearing period of 6–8 weeks and partial weightbearing after 8 weeks, with full weightbearing and physical therapy thereafter.[29] Seijas et al.[30] reported weightbearing after an average of 8 weeks (4–14 weeks). Patients in our own clinic are allowed to progress from partial weightbearing (eggshell) to full weightbearing within 4–6 weeks depending on the size of the lesion. Active plantar flexed and dorsiflexed ankle movements are encouraged within these weeks.[11,32,33]

5.2 Level 2 (Running)

Impact activities, such as running, were first allowed at 12 weeks in the praxis of Saxena and Eakin,[14] Seijas et al.[30] and Ogilvie-Harris and Sarrosa.[31] No other studies mentioned return to running.[27-29] It is also the present senior author's practice to allow running on even ground after 12 weeks.[11,32]

5.3 Level 3 (Non-Contact Sports):

Guo et al.[28] allowed patients to return to sport after 6 months and Chuckpaiwong et al.[27] after 4–6 months, depending on muscle strength. In the study of Lee et al,[29] the ankle activity score by Halasi et al.[24] significantly improved from 3[1-5] to 6,[3-8] and showed that 63% of their patients were returned to their pre-injury sporting level. Ogilvie-Harris and Sarrosa[31] reported in their study that 79% returned to unrestricted sports, 18% played at a lower level and one patient was unable to return. The score on activity level significantly improved to 91% excellent and 9% good.

5.4 Level 4 (Contact Sports)

Saxena and Eakin[14] demonstrated, in high injury-prone patients such as soccer and basketball players, a significantly faster return to activity after treatment with microfracturing (mean ± standard deviation 15.1 ± 4.0 weeks) when compared with patients treated with bone grafting (19.6 ± 5.9 weeks). Arthroscopically treated patients had a faster return to activity (15.8 ± 4.8 weeks), compared with patients treated with an arthrotomy (17.5 ± 5.5 weeks), but the difference was not statistically significant. Seijas et al.[30] reported a return to competition soccer within an average of 20 weeks. In our clinic, a full return to sporting activities is usually possible 4–6 months after surgery.[11,32]

6. Rehabilitation

Return to activity after Achilles tendon ruptures has been described using a 4-level activity scheme.[26] We propose the same approach for determining a return to activity after the debridement and bone marrow stimulation of a talar OD. Return to activity is divided into four levels of increasing intensity: walking, running, return to non-contact sports and return to contact sports (table II). Each of these levels demands specific training and exercises, and each has to be mastered before the next level can be attempted.[26] The patient's activities are systematically expanded and carefully monitored. Each phase ends with specific tests before the speed, force and endurance of the next level can be attempted. The four phases are outlined as follows:

- Level 1: The first level of activity phase is a return to normal walking that commences on the day of the operation with partial weightbearing. Training for ROM is important in this phase. The most important factor is the quality and strength of the tissue repair. The formation of granulation and thereafter fibrocartilaginous tissue starts on the day of the operation. Partial weightbearing provides synovial fluid to nourish chondrocytes. After 6–8 weeks, fibro-cartilaginous tissue is formed and full weightbearing is allowed to further stimulate osteoblasts in the formation of bone underneath the cartilage. At the end of this phase, training of proprioception is commenced to regain normal active stability.
- Level 2: The next level of activity phase is to resume running on even ground. Further

Table II. Return to activity after debridement and bone marrow stimulation of an osteochondral defect

Level	Goal	Training	End terms
1	Return to normal walking	Proprioception Passive and active sagittal ROM Force	Active stability Near normal Force <25% L/R → *Normal walking*
2	Return to running on even ground	Force Technical skills Endurance	Force <12% L/R Sideward movement → *Easy jogging*
3	Return to non-contact sports	Speed Force Endurance	Running even ground Sprinting Force normalized Turning/twisting Rope jumping → *Non-contact sports*
4	Return to contact sports	Speed Force Endurance	Running uneven ground Explosive force Changing direction Sport-specific movements → *Contact sports*

L/R = left/right; **ROM** = range of motion; → indicates end of phase.

training of proprioception might be needed, in case active stability has not yet been achieved. The ROM should be normal. By training for force, endurance and technical skills, the aim is to achieve controlled sideways movement, with the lower-leg force increasing to a left/right difference of less than 12%. After increased activity, pain and swelling should have ceased after 24 hours.

- Level 3: The third level of activity phase is a return to non-contact sports. By means of further training for speed and endurance, running on even ground and sprinting should become possible. At the end of this phase, rope jumping, turning and twisting should also be possible. Some pain may occur after increased activity but should be absent after 24 hours.
- Level 4: This, the highest level of activity phase, is defined as a return to contact sports. Final training for speed, muscle strength and endurance should enable running on uneven ground, generating explosive force, changing direction and other sports-specific movements.

7. Factors that Influence the Time of Rehabilitation

Injuries in sports are common and time consuming. For athletes with an OD, the period before resuming impact sport after surgery was 3–6 months.[12-14] There are several factors that can influence the natural recovery of an OD and, thereby, possibly speed up the rehabilitation and return to sports.

8. Methodology

8.1 Data Sources and Searches

The MEDLINE database was searched again for English-, Dutch- and German-language studies, up to January 2012. The main search headings were 'osteochondral defects', 'bone marrow stimulation', several influencing factors (specified by keywords), 'rehabilitation' and 'talus' and the following keywords used were: 'age', 'BMI', 'defect size', 'mobilization', 'growth factors', 'platelet-rich plasma', 'bisphosphonates', 'hyaluronan', 'PEMF', 'shock waves', 'influencing factors', 'rehabilitation and osteochondral defects', 'osteochondral lesions', 'cartilage defects', 'osteochondritis dissecans', 'transchondral fracture', 'flake fracture', 'talar dome fracture', 'osteochondral fracture', 'osteochondral lesion and healing', 'predictors and microfractur*', 'drilling', 'bone marrow stimulation' and 'ankle, talus'.

8.2 Study Selection

Articles were screened by their title and abstract by one observer (ICMvE) and checked by a second observer (MLR). After selection, full-text articles were read for further screening. Selection criteria were *in vitro* studies using human or animal material, *in vivo* animal studies, randomized controlled trials or clinical trials in which the effects of several influencing factors were studied regarding osteochondral (cartilage) defects in the talus after bone marrow stimulation of the OD.

9. Results

9.1 Age

Animal studies show that cartilage proteoglycans from immature animals are larger than proteoglycans synthesized from chondrocytes of mature animals. It is therefore likely that ODs in mature and elderly individuals heal less effectively than for young individuals.[15] This was supported by two studies, where younger patients with talar ODs had a better functional and clinical outcome after debridement and bone marrow stimulation.[7,27] However, another clinical study failed to show that older age is an independent predictor for clinical failure after arthroscopic treatment.[34]

9.2 Body Mass Index

Patients with a lower body mass index (BMI) have a better functional outcome after debridement and bone marrow stimulation of ODs in the talus.[27]

9.3 Defect Size

An animal study has demonstrated that larger defects are less likely to recover completely.[35] Clinically, the larger the defect size, the less likely a functional outcome for patients after debridement and bone marrow stimulation of the talus.[27,28] The cutoff point is approximately 15 mm.[36]

9.4 Hyaluronic Acid

Intra-articular hyaluronic acid injections in animals improve the repair of ODs by a better fill and a more structural repair of the defect.[37,38] However, Saw et al.[39] demonstrated in goats no significant difference in cartilage repair of ODs after bone marrow stimulation treated with hyaluronic acid injections, compared with no additional treatment.

Clinically, an intra-articular injection of hyaluronic acid after debridement and bone marrow stimulation has shown to be effective, both lessening pain and improving ankle function.[40]

9.5 Mobilization

In vitro, immobilization of a joint leads to fibrillation, decreased proteoglycan content and synthesis and altered proteoglycan conformation, such as a decrease in the size of aggregates and amount of aggregate (partly by diminished nutritive transport to cartilage from synovial fluid).[41] Moreover, the mechanical properties of articular cartilage are compromised by immobilization, although these biomechanical and biochemical changes are reversible by mobilization of the joint.[41] In animal studies, mobilization leads to thicker and stiffer cartilage with a greater concentration of endogenous proteoglycan.[42-46]

9.6 Platelet-Rich Plasma

In vitro data shows a higher rate of proteoglycan synthesis and accumulation as well as collagen synthesis with treatment of platelet-rich plasma (PRP).[47] PRP treatment also enhances mesenchymal stem cell (MSC) proliferation, that could improve the filling of ODs after bone marrow stimulation.[48] In animal studies, PRP treatment leads to more neo-chondrogenesis and glycosaminoglycans in the OD after 4 weeks and to more hyaline tissue after 12 weeks. The amount of subchondral bone is larger in the group treated with PRP.[49] PRP-gel and liquid PRP injection after bone marrow stimulation leads to better repair tissue than that of solely bone marrow stimulation of the OD.[50]

9.7 Growth Factors

9.7.1 Autologous Preparation Rich in Growth Factors

An animal study shows autologous platelets injected in osteochondral defects to have better

chondral cellularity and regeneration, and less fibrosis.[51]

The use of injections with autologous PRGF has been compared with hyaluronic acid injections in a retrospective study[52] that demonstrated a significant difference in favour of treatment with PRGF for pain, physical function and overall WOMAC Score (Western Ontario and McMaster Universities Osteoarthritis Index Score).[52]

9.7.2 Insulin-Like Growth Factor

In vitro data shows that IGF-1 stimulates the extracellular matrix and decreases matrix catabolism.[53]

Animal studies have demonstrated that treatment with IGF-1 results in an increased number of chondrocyte-like cells that are more orderly and better attached to the underlying bone, have a better integration of repair tissue with the surrounding normal articular cartilage and an upregulation of type II collagen.[54-57] When IGF-1 is injected intra-articular into the knee of horses, it increases the synthesis of type II collagen and proteoglycan.[58]

9.7.3 Bone Morphogenic Proteins

In vitro data shows that BMP-2 stimulates matrix synthesis and increases the synthesis of collagen type IIB in chondrocytes.[41] BMP-7 is known to stimulate cartilage matrix synthesis and to decrease catabolic activity of interleukin (IL)-1, IL-6, IL-8, matrix metalloproteinase (MMP)-1 and MMP-13.[59] Animal studies show BMP-7 to cover more area after bone marrow stimulation and to improve matrix and cell distribution.[60]

9.7.4 Platelet-Derived Growth Factor

In an animal study, treatment with PDGF increased the chondrocyte proliferation and upregulation of proteoglycan synthesis.[56]

9.7.5 Transforming Growth Factor-β1

In vitro, TGF-β1 stimulates *de novo* synthesis of matrix macromolecules, as well as stimulation of chondrogenesis of synovial lining and bone-marrow-derived MSCs.[61,62]

9.8 Pulse Electromagnetic Fields

In vitro studies show improved bone development, increased chondrocyte proliferation and increased proteoglycan synthesis with down-regulation of IL-1 and stimulation of TGF-β and IGF-1 after treatment with PEMFs.[63-69]

In an animal study, PEMFs stimulated osteoblast activity during the healing process of an OD.[70] Clinically, PEMF treatment improves the functional recovery of patients after arthroscopic treatment of chondral lesions in the knee, and reduces the use of non-steroidal anti-inflammatory drugs.[71]

A double-blind, randomized controlled trial started in 2008 that will hopefully provide information about the efficiency of treatment with PEMF in patients with an OD in the talus.[33]

9.9 Shockwaves

In vitro, the expression of TGF-β1 in defect tissues is increased after shockwave treatment.[72] An animal study showed more hyaline-like cartilage with more proteoglycans and rich blood vessels at the bottom of an OD after bone marrow stimulation with shockwave therapy, compared with bone marrow stimulation alone.[73]

9.10 Bisphosphonate

An animal study showed acceleration of subchondral bone repair during the early stages and better cartilage quality after treatment with bisphoshonates (alendronate).[74]

10. Discussion

The purpose of this paper was to delineate levels of activity, to determine the time for return to activity, and to review the factors that influence rehabilitation after arthroscopic debridement and bone marrow stimulation of a talar OD.

It became clear that there is not much published on the subject, and the literature shows no consensus about rehabilitation and return to activity. For instance, weightbearing is variously tolerated from immediately after to 8 weeks after surgery and time for return to activity after

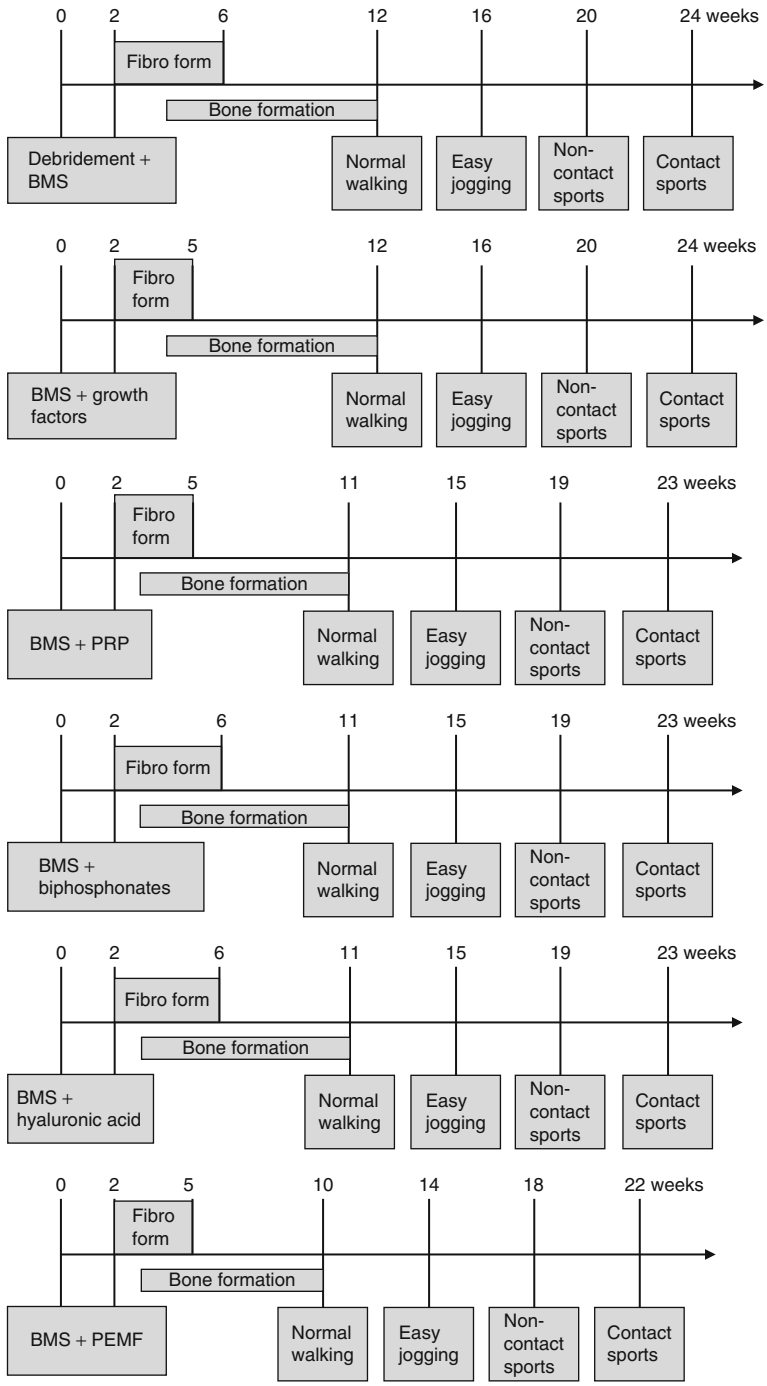

Fig. 3. Surgical treatment (debridement and bone marrow stimulation) of osteochondral talar defects and the influence of several factors for faster rehabilitation. **BMS** = bone marrow stimulation; **Fibro form** = fibrocartilage formation; **PEMF** = pulse electromagnetic fields; **PRP** = platelet-rich plasma.

debridement and bone marrow stimulation is also variable.[14,27-31] Most authors advise a period of 6–8 weeks of non-weightbearing or partial weightbearing.[14,27-31]

For the return to activity after surgery, we propose a four-level activity scheme. Before returning to contact sports, the patient has to first achieve the level of normal walking, followed by the level of running and then the level of non-contact sports.[26] This simple scale can be used for rehabilitation protocols after operative treatment of talar ODs.

There is evidence that a younger age, lower BMI, smaller defect size and post-operative intra-articular hyaluronic acid injections are correlated with a better functional outcome. However, whether these factors shorten the rehabilitation period has not been investigated. Mobilization has been shown to result, in both animal and *in vitro* studies, in thicker and stiffer cartilage with a greater concentration of endogenous proteoglycan. And the negative effects of immobilization can be reversed by mobilization.

After ankle fractures, early weightbearing has been demonstrated to increase blood flow, reduce muscle atrophy,[75,76] improve the ROM,[77] result in earlier rehabilitation[78-80] and lead to a higher proportion of patients regaining symmetrical gait after surgery.[81] However, the reason for cartilage and subchondral bone recovery after bone marrow stimulation is still unknown. To protect the fibrin clot and the formation of granulation tissue, patients are generally kept on a partial weightbearing protocol.[11,32,33] Marder et al.[82] showed no difference in the post-operative policy of 6 weeks touchdown weightbearing with continuous passive motion or weightbearing, as tolerated with intermittent active motion.[82] This would indicate that it is possible to start with an earlier but controlled weightbearing without harming the repair site.

As most patients with an OD are young and athletic, an extended rehabilitation with longer time for a return to sport severely impacts on their quality of life. Factors that can improve the rehabilitation time are outlined as follows (figure 3): Several growth factors and PRP are shown to influence recovery after bone marrow stimulation of ODs. These effects have been demonstrated in *in vitro* and animal studies. Treatment with bisphosphonates and shockwaves were likewise investigated *in vitro* in animals, and showed a positive effect. PEMF treatment has been studied in vitro in animal and clinical studies and was shown to be effective.[63-69,71]

Most of those studies have examined the knee joint. Nonetheless the ankle joint is more congruent, and talar articular cartilage is thinner when compared with distal femoral cartilage.[83,84] Additionally, the load-bearing contact surface is larger in the ankle joint, and most of the ODs in the talus are smaller than in the knee joint. This could be the reason for different results from the same treatments in the ankle and the knee. Furthermore, animal joints, for example the horse, as used in OD experiments, don't replicate the anatomical, cellular and biomechanical properties of the human joints.[85,86]

11. Conclusion

It is advised that the time for a return to full weightbearing in patients with a talar OD treated by means of debridement and bone marrow stimulation is currently 6–8 weeks. Further rehabilitation depends on the desired level of activity. To return to contact sports, patients first have to achieve the level of normal walking, followed by running and return to non-contact sports. As most patients with an OD are young and athletic, a faster rehabilitation will improve the quality of life in these patients. Potential factors reducing the rehabilitation time are a younger age, lower BMI, smaller defect size, mobilization and treatment with growth factors, PRP, bisphosphonates, hyaluronic acid and PEMF. Since most factors are investigated *in vitro* and in animal studies, more research on potentially influencing factors is needed for talar ODs in humans.

Acknowledgements

No funding was received to assist in the preparation of this review. The authors have no conflicts of interest to declare that are directly relevant to the content of this review.

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