# Biological Reconstruction in Patients with Osteochondral Defects: Postoperative Management and MRI Monitoring

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## Contents



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## 47.1 Introduction

Articular surface lesions can be limited to cartilage or can extend to the underlying subchondral bone as it is observed in osteochondritis dissecans (OCD), osteonecrosis, and osteochondral fractures.

The subchondral bone plays an important role even in the articular cartilage defects, since even focal chondral lesions, if left untreated, may increase in size over time and result in concomitant changes in the subchondral bone plate, either overgrowth or bone loss.

The fact is that the articular cartilage and underlying bone are tightly combined and should be considered as one osteochondral anatomical and biomechanical unit, treatment of osteochondral defects should be addressed to restore both cartilage and subchondral bone stock.

Deep osteochondral defects should be treated with surgical techniques which reconstruct either bone or chondral layers of the defect. Authors propose to divide currently used methods into four groups: osteochondral transfers, biologic, hybrid, and synthetic reconstruction methods. The type of reconstruction method implies specific postoperative treatment, and so more important, a rehabilitation protocol should be individually modified. In our opinion, the best way for proper controlling of the osteochondral graft maturation is periodically checkout of the graft status. In our center, patients


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after osteochondral regeneration procedure are followed with the monitoring MR protocol after 3 or 6 weeks subsequently 6 and 12 months postoperatively. Depending on the bone layer with subchondral lamina quality, patients might be allowed for more physical activity or restricted within. In cases of the slow maturation process, physicians may modify pharmacotherapy or/and physiotherapy.

## 47.2 Osteochondral Defect Reconstruction: Current Clinical Procedures

The subchondral bone of lower elasticity is normally present to absorb the forces generated during weight-bearing, protecting the cartilage layer. In fact, surgical treatment should always aim to reestablish the joint surface in the most anatomical way possible. Respectively, after cartilage repair, the regenerative tissue needs support from healthy subchondral bone; otherwise, the overlying cartilage repair will fail. This supporting bone should be strong and elastic [1]. Focal osteochondral defects of the lower limb joints have to be considered for the bone layer reconstruction before chondral layer addressing when the depth of the bone defect is over 2 mm. However, most of the bioengineered tissues used in clinical practice were designed to promote healing of the cartilage layer only but do not regenerate the bone [2].

The spectrum of treatment of the osteochondral lesions is comprised of several techniques including the use of osteochondral allografts, autologous bone and osteochondral grafting, and cell-based implants. Small to moderate lesions can be treated by implantation of autologous osteochondral grafts (OATS) to address both the osseous and cartilaginous defects [3]. This technique in an excellent way restores both the bone bed and overlying hyaline cartilage, and the clinical results described in literature are very encouraging [4]. Nevertheless there are some concerns. The procedure is demanding and surgical experience is required to achieve a good result. Incongruity of the articular cartilage following osteochondral transplantation, especially after mosaicplasty, affects surface contact pressure [5, 6]. Besides, appropriate choice of the donor site is crucial to better match the recipient site [7]. The biomechanical perturbations caused by osteochondral alterations substantially alter pattern and magnitude of contact pressures and cartilage load in the joint. The preferred treatment for OCD lesions and osteochondral fractures is primary osteosynthesis. If the chronic, sclerotic OCD lesion or comminuted osteochondral fracture cannot be repaired in that way reconstruction of the defect, the bone grafting and concomitant or staged cartilage repair can be performed. Iliac crest bone graft is most commonly used for bone autograft; however, this harvest site is often associated with postoperative pain. The use of autologous cancellous bone from the proximal tibia or distal femur through a cortical window, frequently through the same skin incision, results in excellent outcomes [8]. For smaller defects, there is no need for additional fixation of the graft material. In larger defects, a layer of fibrin glue is commonly added. The procedure can be performed with collagen matrix coverage, to promote chondrogenesis on the bone graft surface. This was first described by Peterson et al. and called “sandwich technique” [9]. Moderate to larger-sized defects can be treated using this technique. There are many ways for the restoration of the superficial layer of the osteochondral defect in the sandwich technique. In the last 25 years, first- and second-generation autologous chondrocyte implantations have emerged as a promising therapeutic option, and many trials have confirmed the good clinical results of these treatments [2]. The subchondral bone stock restoration together with matrix-assisted chondrocyte implantation (MACI) as well as some others like bone marrow aspirate concentrate with hyaluronic matrix (HA-BMAC) uses tissue engineering technology to create a cartilage-like tissue in a three-dimensional architecture [10]. It could be performed either as an open surgery or so-called dry arthroscopy [11]. Indications for osteochondral allograft transplantation include osteochondritis dissecans (OCD), the revision of failed prior cartilage repair procedures. This technique allows replacement of the entire osteochondral unit, thus avoiding the potential negative effects of altered subchondral bone on cell-based therapy procedures. An optimal defect to treat with osteochondral grafting is lesion larger than 3–4 $cm^2$, localized in the femoral condyles. Kissing lesions are relative contraindications, and the result of surgery is less predictable. Specific complications include the risk of disease transmission (HIV, hepatitis), which is estimated at less than 1:150000. Midterm follow-up studies have demonstrated survival of more than 80% of grafts at 3–10 years [12]. Large osteochondral defects of the femoral condyle can be treated by transplantation of the autologous posterior femoral condyle – mega-OATS [13]. Some authors support data for synthetic biphasic scaffolds, which they believe to reproduce the different biological and functional requirements for guiding the growth of the two tissues (bone and cartilage). New scaffolds with osteochondral regenerative potential have been developed and evaluated with promising preliminary results [14–16]. In the study of Stone et al., with up to 23-year FU, good clinical results can be achieved with the use of cartilage paste graft for severe osteochondral lesions of the knee [17]. In order to provide three-dimensional autogenous cartilage matrix with chondrocytes to large defects, an osteochondral plug is harvested from the intercondylar notch, crushed into a paste, and impacted into the fractured chondral defect.

Considering similarities of currently used osteochondral reconstruction methods in clinical practice, we advocate a four-group classification as follow:

**Group 1 Osteochondral transfers:**

- Osteochondral autograft (OATS)
- Mosaicplasty/OATS
- Osteochondral allograft (allo-OATS)
- Massive osteochondral auto- or allografts (mega OATS)

**Group 2 Biologic osteochondral reconstruction:**

- Morselized bone implantation or autologous bone block implantation (e.g., spongiosa block from the iliac crest) covered with:
- Autologous matrix-induced chondrogenesis (AMIC-like procedures)
- Autologous chondrocyte implantation with periosteum (ACI-P), 1 gen. (sandwich technique)
- Autologous chondrocyte implantation with scaffold (ACI-C), 2 gen.
- Matrix induced autologous chondrocyte implantation (MACI), 3 gen.
- Bone marrow aspirate concentrate with collagen scaffold
- Bone marrow aspirate concentrate with hyaluronic scaffold – HA-BMAC (BIOR)
- Other biological covering
- Morselized autologous osteochondral implantation (PASTA)

**Group 3 Hybrid osteochondral reconstruction:**

- Bone substitute implantation covered with:
- Autologous matrix-induced chondrogenesis (AMIC-like procedures)
- Autologous chondrocyte implantation with scaffold (ACI-C), 2 gen.
- Marrow aspirate concentrate with a scaffold
- Other biological covering

**Group 4 Synthetic osteochondral reconstruction:**

- Biphase scaffolds (Agili-C®, BioMatrix CRD®, Trufit®, and others)
- Three-phase scaffolds (MaioRegen®)

## 47.3 Postoperative Treatment

### 47.3.1 Postoperative Treatment after Osteochondral Transfers

The complete postoperative management program after OATS includes information about weight-bearing, immobilization, range of motion, and expected time until return to previous activity levels. Patients are kept in a brace for a maximum of 2 weeks after surgery. During this period, isometric muscle strengthening exercises are encouraged [18]. Weight-bearing exercises are not permitted until 4 weeks after surgery [18–23]. Subsequently, weight-bearing

**Table 47.1** The rules of postoperative management after osteochondral transfers by the recent publications

| Author | Weight-bearing status | Keeping in brace | Range of motion | Return to previous activity |
|---|---|---|---|---|
| De Caro [24] | Related to associated procedures | For 4–6 weeks | Full immediately | In 79% of patients, no information about time |
| Solheim [19] | Foot touch for at least 6 weeks<br>Full introduced gradually | n/a | Full immediately | n/a |
| Ollat [20] | Full after 7 weeks | n/a | n/a | In 34 weeks (7–8 months), rate for 73% of cases |
| Sadr [21] | Full after 4–12 weeks depending on the size of the lesion | n/a | Full immediately | Between 4 and 6 months |
| Imade [18] | Not permitted for 4 weeks after surgery, full after 8 weeks | 2 weeks after surgery | Full after 2 weeks | After 3 months |
| Gudas [22] | Not permitted for 4 weeks after surgery, full after 8 weeks | Not used | Full immediately | Between 4 and 6 months |
| Filardo [23] | Progressively after 4 weeks, full at 8 week | n/a | 90° of flexion until 2 weeks | n/a |

is gradually progressed, with full weight-bearing expected by the end of the eighth postoperative week [18, 19, 22, 23]. Range of motion exercises are allowed immediately after surgery [19, 21, 22, 24], and closed-chain exercises are permitted after week 4. Unrestricted activities of daily living begin between 2 and 3 months postoperatively [21]. Finally, return to recreational and athletic activities is typically achieved between 4 and 6 months after surgery but is only allowed if the lower extremity demonstrates full functional recovery [18, 22, 23]. According to previously published data, the overall rate of return to previous activities is 88% [24], and the rate of return to previous levels of sport is 73–79% [20, 24]. The general rules of postoperative treatment in patients after osteochondral transfer by the recent publications are presented in Table 47.1.

### 47.3.2 Postoperative Treatment after Synthetic Osteochondral Reconstruction

Early isometric and isotonic exercises are begun on the second postoperative day, and controlled mechanical compression is performed [25, 26]. Knee swelling is treated with ice packs that are applied over the joint for 20 min, four times per day, after rehabilitation sessions [27]. Neuromuscular electrical stimulation is allowed in addition to voluntary muscular contractions. Between 6 and 8 weeks postoperatively, gait training in a swimming pool is recommended to restore normal gait. When the patient regains full knee extension, at least 120° of knee flexion, and has normalized the gait pattern, open and closed kinetic chain strengthening exercises are encouraged, within a pain-free range of motion, together with proprioceptive exercises and aerobic training. After sufficient strength recovery is achieved, as evaluated by clinical examination with performance of a one-legged hop test 20% compared with the contralateral limb, patients begin sport-specific training through eccentric strengthening and advanced proprioceptive exercises [26]. Progression of patient rehabilitation may be adversely affected over the postoperative period by such factors as fever, joint stiffness, marked swelling, and bleeding [25–27]. In these studies about treatment of the knee, osteochondral lesions with a synthetic scaffold showed a promising clinical

**Table 47.2** The rules of postoperative management after synthetic osteochondral reconstruction methods by the recent publications

| Author | Weight-bearing status | Range of motion | Return to previous activity |
|---|---|---|---|
| Kon [27] | Prohibited or partial with external distractor, full between 6 and 8 weeks | Full immediately | Stable at 24 months, but lower than pre-injury level |
| Berutto [25] | Full introduced gradually with crutches, till 6 or 8 weeks | Full immediately | Athletes with statistically significant improvement compared with the nonathletic subpopulation at the 2-year follow-up |
| Filardo [26] | 3–4-week weight touchdown with crutches | Full the second day after surgery | Lower but not statistically significant |

**Table 47.3** The rules of postoperative management after biologic osteochondral reconstruction methods in the ankle joint by the recent publications

| Author | Weight- bearing status | Keeping in brace | Range of motion | Return to previous activity |
|---|---|---|---|---|
| Sadlik [28] | 0–2 weeks none, next 4–6 weeks partial (15 kg), next 6–8 weeks progressively full | 2-week short ankle orthosis, a walker for 6 weeks when malleolus osteotomy | Between 2 and 7 weeks increasingly passive full ROM | After 6–8 weeks: swimming and cycling, after 5–6 months competitive depending on MRI status |
| Valderrabano [29] | First 6 weeks partial (15 kg), up to 12 weeks progressive to full | A walker for 6 weeks | From max. 20° till 6 weeks | After 12 weeks: swimming and cycling, after 5–6 months competitive |
| Wiewiorski [30] | Partial for 6 weeks (max 20 kg), full under intense physical therapy progressively | Functional orthosis for 6 weeks | Max. 30° till 6 weeks | n/a |

outcome at the short-term follow-up. The activity level was stable at 24 months, although it did not reach the pre-injury level [25–27]. Moreover, the athletic subpopulation showed a statistically significant improvement compared with the nonathletic subpopulation at the 2-year follow-up [26] (Table 47.2).

### 47.3.3 Postoperative Treatment after Biologic or Hybrid Osteochondral Reconstruction

The rehabilitation protocol after biologic or hybrid surgical treatment of osteochondral injury is based on descripted by a surgeon the size and location of the osteochondral defect and the contact angle (CA). CA means the range of the joint motion when the reconstructed articular surface being in contact with the opposite surface. This is a very important information for a physiotherapist which allows the knowledge for the safe ROM designation in progression of the exercise. CA is usually useful for the joint knee osteochondral reconstruction on the contrary to the ankle joint where the CA includes full range of motion, due to high congruency of that specific joint. There is insufficient actual data in terms of rehabilitation protocol for biological osteochondral reconstructions in the knee. Because this kind of treatment is more common in the ankle joint, there are some current publications describing rehabilitation protocol for that procedure (Table 47.3).

In the authors' experience, the individual rehabilitation strategy should be planned with taking into account four key issues as follow:

- Restricted joint motion within initial graft integration period as the first 7–10 days, in order to successfully integrate the graft and to allow formation of fibrous hematoma on its interface, after the first period of the graft integration, progressively increasing of the joint motion up to full range applying passive mobilization with the joint distraction.
- MRI monitoring of the graft maturation at 3 or 6 weeks subsequently 6 and 12 months after the surgery.
- Orthopedic equipment should be individualized depending on the size, location, and CA of the osteochondral reconstructed defect.

In all cases, the rehabilitation process should be modified depending on the joint status as swelling, adhesion, additional procedures or injures, as well as MRI assessment.

In the first 7–10 days, we recommend limiting joint motion, in order to encourage successful integration of the repair tissue and the formation of fibrous hematoma. After this period, range of motion exercises are begun in conjunction with joint distraction. Partial weight-bearing should begin 4 weeks after surgery, with expected unrestricted weight-bearing by week 6. It is important for the physiotherapist to be knowledgeable with respect to the goal of restoring the anatomic curvature of the articular surface, as there are designated safe ROM limitations that progress over time to address this. To optimize postoperative monitoring of the healing process and formation of repair tissue, it is recommended that patients undergo MR at 6 and 12 weeks after surgery. At 3 months, patients progress to straight-line running, with an emphasis on strength, endurance, and aerobic training. Sport-specific training typically begins at 8 months, with expected return to competition by 10 months postoperatively.

## 47.4 Summary

Most of the rehabilitation centers use standard postoperative rehabilitation protocols after the knee and ankle osteochondral lesion surgical treatment. Management can be various, depending on a lesion size and localization, comorbidities, and a patient age. The late postoperative management, considering various physical activities of the patients, should be administered with functional tests and graft maturation rate in MRI. Various graft maturation dynamic in MRI assessment can be seen. There is noticeable slower graft rebuilding progress in the older patients. For example, in a 54-year-old man, who developed lateral condyle OCD, after biological inlay implantation (30 × 20 × 10 mm), a full osteochondral graft rebuilding was noticed until after 18 months in MRI (Figs. 47.1 and 47.2). Another case of the osteochondral inlay of the lateral femoral condyle of a 24-year-old soccer player presents very fast rebuilding of the osteochondral graft allowing return on the field within 6 months postoperatively. The biological osteochondral reconstructions of the talar dome seem to be slower in the maturation than the knee which is presented in Fig. 47.3. 46 old female with the talar dome biological inlay reconstruction. MRI monitoring of the lesser osteochondral defects is very useful following conservative treatment. In some cases, a small OCL can be visible quickly progress of the defect which finally has to be treated surgically as the one shown in Fig. 47.4. In fact, there is no simple way

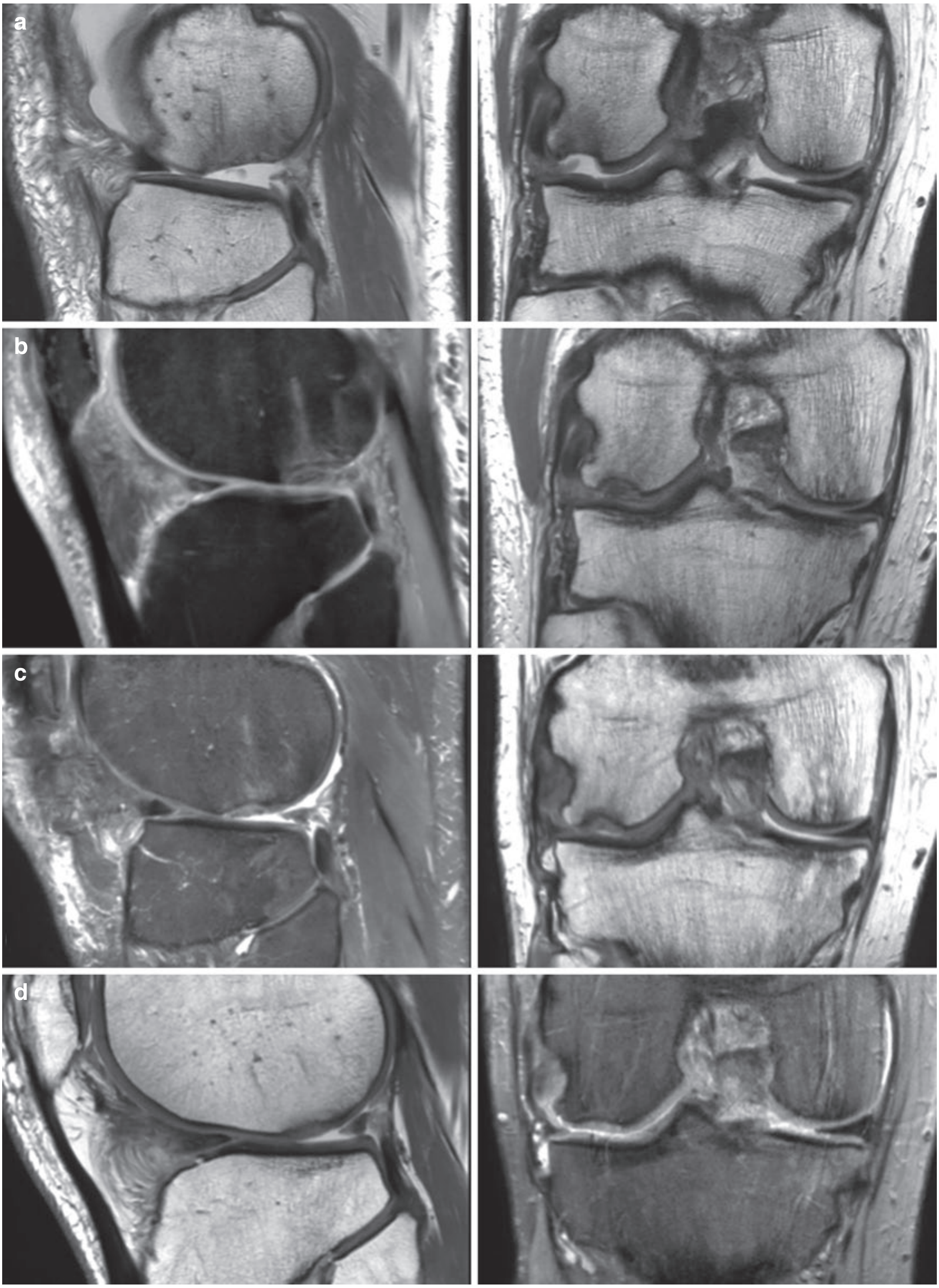



**Fig. 47.1** Remodeling of the biological inlay. MRI evaluation of the right knee of a 54-year-old male regarding the stepwise remodeling of the subchondral lamina and chondral surface sagittal and coronal scans: (**a**) osteochondral defect grade IV of the lateral femoral condyle, preoperatively; (**b**) biological osteochondral inlay, 3 months postoperatively; (**c**) 6 months postoperatively; (**d**) 18 months postoperatively; proton density (PD) with or without fat saturation (FS) (m-SPIRE, 3.0 Tesla digital scanner) and sagittal and coronal scans

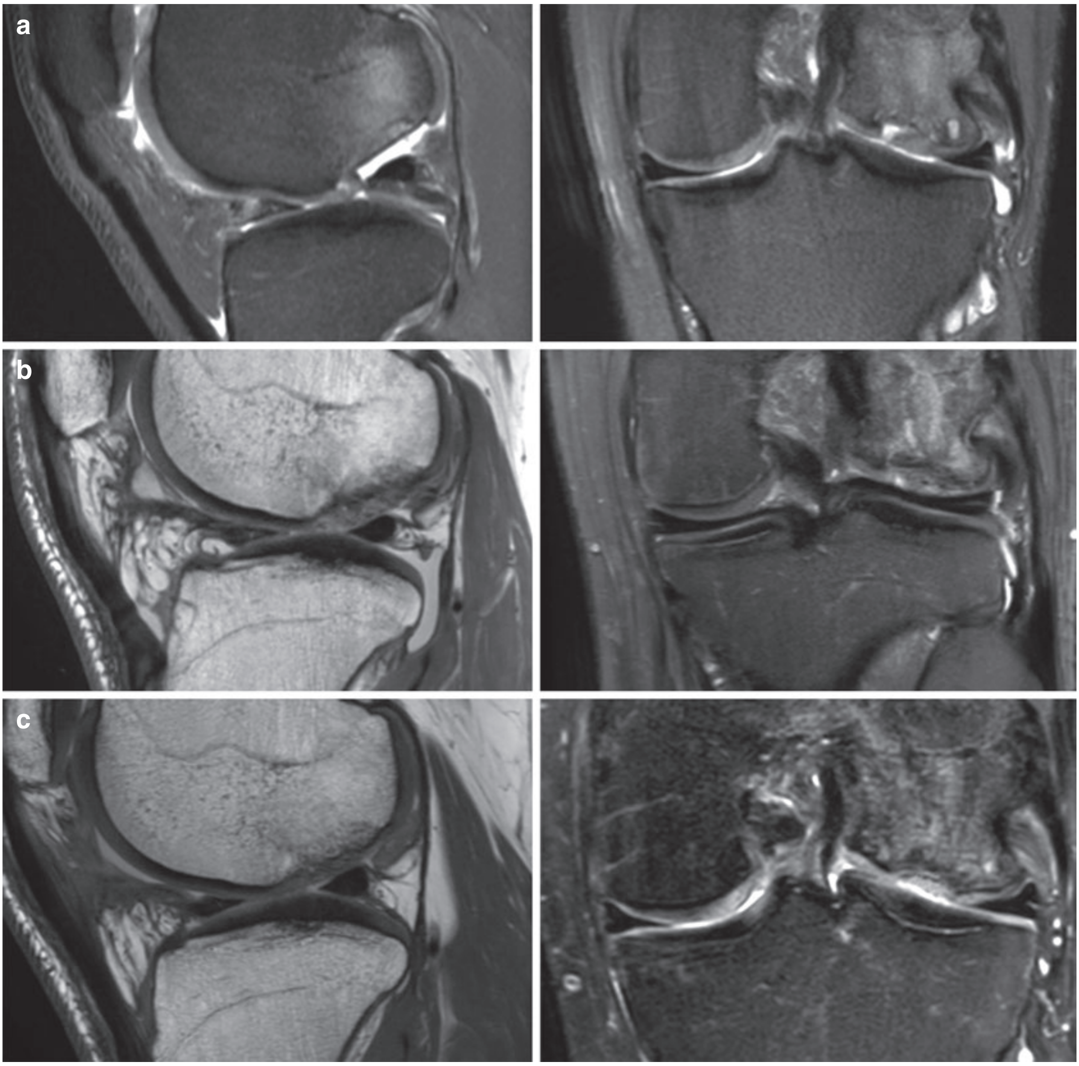
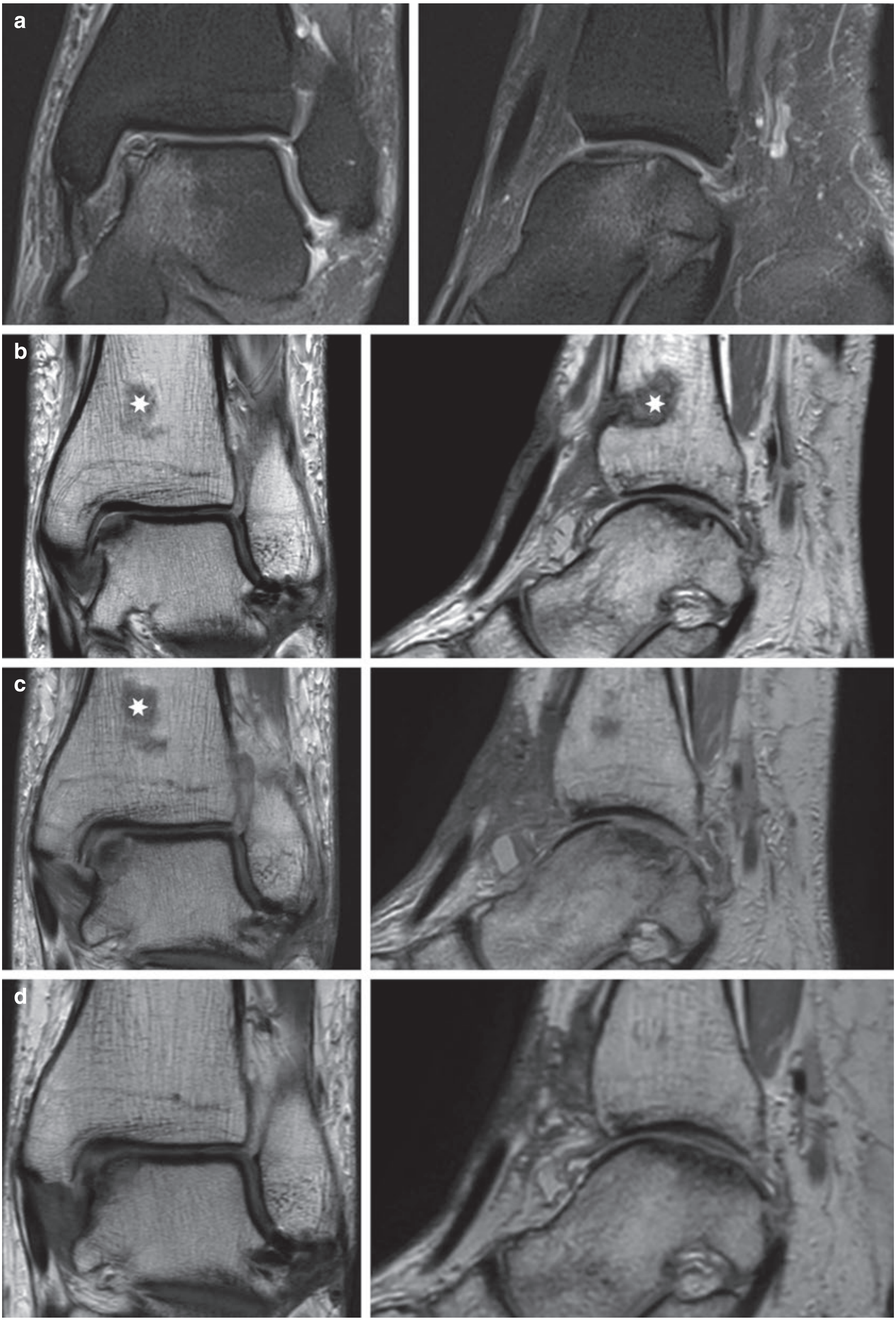


**Fig. 47.2** An example of fast remodeling of the biological inlay. MRI evaluation of the left knee of a 24-year-old male regarding the stepwise remodeling of the subchondral lamina and chondral surface: (**a**) osteochondritis dissecans grade IV of the lateral femoral condyle, preoperatively; (**b**) biological osteochondral inlay, 3 months postoperatively; (**c**) 6 months postoperatively, a border of subchondral lamina and chondral surface are clearly visible, bone edema slightly decreased ; proton density (PD) with or without fat saturation (FS) (m-SPIRE, 3.0 Tesla digital scanner) and sagittal and coronal scans

**Fig. 47.3** An example of slow remodeling of the biological inlay of medial talus. MRI evaluation of the left ankle of a 48-year-old female regarding the stepwise remodeling of the subchondral lamina and chondral surface: (**a**) osteochondral defect grade III of the medial aspect of the talar dome, preoperatively; (**b**) biological osteochondral inlay (asterisk, donor site of a spongiosa bone graft), shape of the talar dome properly formed (3 months postoperatively); (**c**) still proper shape of the talar dome, subchondral lamina not visible yet (12 months postoperatively); (**d**) subchondral lamina and chondral layer visible (24 months postoperatively); PD (proton density) with or without fat saturation (m-SPIRE, 3.0 Tesla digital scanner); sagittal and coronal scans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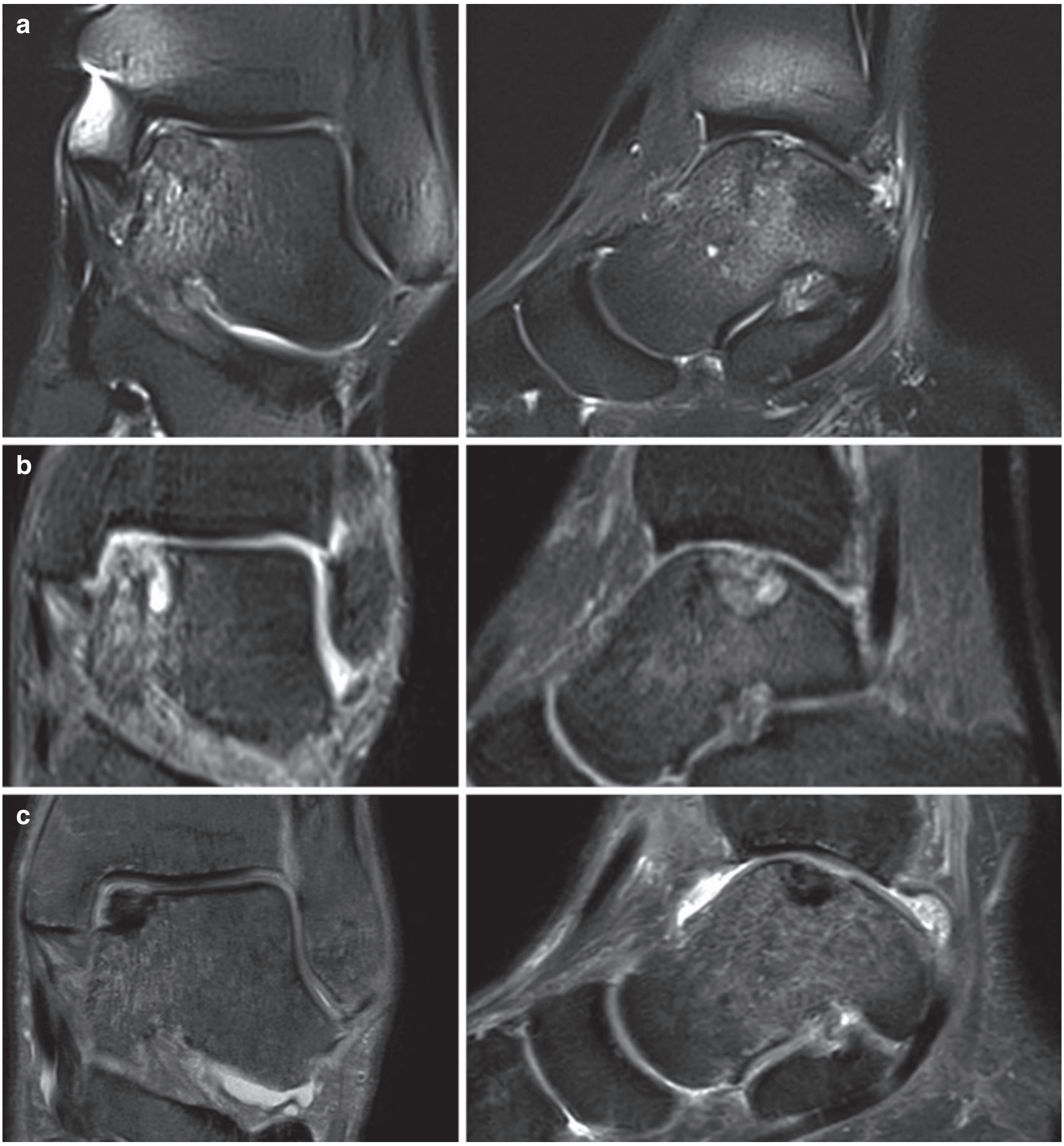


**Fig. 47.4** Natural history of OLT: (**a**) the first MRI at the beginning of the ankle pain (2 years before surgery), only chondral lesion and subchondral bone edema can be seen on the medial shoulder of the talus; (**b**) MRI scans 2 months before surgery, chondral lesion and edema extended and several pseudocysts appeared in the region of talar edema. MRI 2 months after OLT reconstruction with BIOR technique; (**c**) talar dome curvature and structure were restored; PD (proton density) with or without fat saturation (m-SPIRE, 3.0 Tesla digital scanner) and sagittal and coronal scans

to perform postoperative treatment and rehabilitation in group of patients with osteochondral reconstruction of the joint, because the biological processes of grafts are not well known and uncontrolled in vivo.

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