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Authors
Motamedi, Kambiz
Seeger, Leanne L
Hame, Sharon L

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Imaging of postoperative knee extensor mechanism

Kambiz Motamedi [a,*], Leanne L. Seeger [b], Sharon L. Hame [c]

[a] David Geffen School of Medicine at UCLA, Musculoskeletal Imaging-Department of Radiology, 200 Medical Plaza, Suite 165-59, Los Angeles, CA 90095, USA
[b] David Geffen School of Medicine at UCLA, Musculoskeletal Imaging-Department of Radiology, 200 Medical Plaza, Suite 165-57, Los Angeles, CA 90095, USA
[c] David Geffen School of Medicine at UCLA, Department of Orthopedic Surgery, Box 956902, 76-143 CHS, Los Angeles, CA 90095, USA

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Abstract

Disorders of the anterior knee are common and include patellofemoral syndrome, patella instability, patella fracture, and patellar and quadriceps tendon ruptures. Depending on the operative procedure performed, the post-operative imaging appearance of these knees may be confusing. It is crucial for the radiologist to be familiar with the procedures performed in order to recognize the postoperative findings. Radiologists must be able to interpret hardware (anchors, screw and wires) and disruptions in soft tissue planes that may persist with these types of procedures.

Keywords: Knee extensor; Anterior knee syndrome; Post-operative imaging; Realignment surgery

1. Introduction

Disorders of the anterior knee are common and include patellofemoral syndrome, patella instability, patella fracture, and patellar and quadriceps tendon ruptures [1]. Even though the majority of clinical disorders are treated conservatively, some require surgical intervention [2,3]. Depending on the operative procedure performed, the post-operative imaging appearance of these knees may be confusing. It is crucial for the radiologist to be familiar with the procedures performed in order to recognize the postoperative findings. Radiologists must be able to interpret hardware (anchors, screw and wires) and disruptions in soft tissue planes that may persist with these types of procedures.

The extensor mechanism of the knee is an intertwined net of tendinous, capsular and ligamentous tissues, which enables a mechanically optimal insertion of the quadriceps muscles to the proximal tibia. The tendons of the vastus muscles (intermedius, medialis and lateralis) and the rectus femoris come together distally to form the quadriceps tendon. This attaches to the upper pole of the patella. The fibers of the patellar tendon extend from the inferior pole of the patella to the tibial tuberosity. There are continuous fibers between quadriceps and patellar tendons traversing the anterior aspect of the patella, making the patella anatomically and physiologically a sesamoid bone [4].

The terms patellar tendon and patellar ligament have been used interchangeably in the literature, and refer to the infrapatellar portion of the quadriceps mechanism. The cartilaginous surface of the patella articulates with the intercondylar or trochlear groove of the femur, a surface that is also lined with hyaline cartilage. This configuration allows for smooth gliding of the large extensor tendon over the distal femur during flexion and extension.

In addition to the patellofemoral articulation, alignment of the extensor mechanism is further maintained by the medial patellar retinaculum. This structure resists the “natural” lateral and posterior pull on the patella by the constellation of the extensor structures. The medial patellar retinaculum is comprised of layers described as fascial condensations rather than true separate ligaments. The most superficial layer I consists of the deep fascia of the subcutaneous compartment. Layer II includes the medial patellofemoral ligament (MPFL), the superficial medial collateral ligament (MCL) and the patel-

* Corresponding author. Tel.: +1 310 206 9378; fax: +1 310 794 1428.

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Fig. 1. (a) Anteroposterior view of the knee shows a circular tension wire and two Kirschner wires fixating a patellar waist fracture. (b) Axial fat-saturated T2-weighted image shows the ferromagnetic artifact caused by the wire. Note that a horizontal phase encoding axis was chosen to avoid the artifact obscuring the patellofemoral articulation. Also note the incomplete fat-saturation of the patella due to field inhomogeneity caused by the presence of the wires. (c) Sagittal gradient echo localizer image shows the blooming artifact caused by the hardware. In general, gradient echo sequences should be avoided when dealing with hardware.

lotibial ligament. These structures merge with layer III, which is the portion of the joint capsule deep to MCL, sometimes referred to as the medial capsular ligament. Though not a part of the medial patellar retinaculum, the vastus medialis oblique (VMO) muscle participates in stability of the knee extensor mechanism by contributing fibers to the superficial layer of the MPFL prior to inserting directly onto the superior and medial aspect of the patella [5].

(a)

(b)

Fig. 2. (a) Lateral knee radiograph depicts three suture anchors reattaching the patellar tendon to the proximal tibia and (b) sagittal T1-weighted image shows the ferromagnetic artifact caused by the suture anchors. Note the thickened distal patella tendon from prior tea.

Fig. 3. Lateral radiograph shows tension wire fixation of a patellar tendon tear.

Fig. 4. Sagittal proton density image shows stranding of the Hoffa fat pad, indicating scar tissue from prior arthroscopy port placement.

2. Extensor mechanism disorders

Patellofemoral pathology includes several discrete entities. Traumatic injuries include acute patellar fracture and quadriceps or patellar tendon rupture. Overuse injuries related to repetitive trauma include patellar tendonitis (jumper's knee), quadriceps tendonitis, and iliotibial band syndrome. Late effects of trauma may include patellofemoral arthritis and anterior fat pad syndrome (Hoffa disease) [1].

The lateral patellar compression syndrome is a disorder caused by a tight lateral retinaculum leading to lateral patellar tilt, without excessive patellar mobility.

Patellar instability refers to recurrent subluxations and/or dislocations of the patella. Abnormalities of patellar height may also be present (high-riding patella alta, or low-riding patella baja).

Patellar chondromalacia is a common disorder that causes anterior knee symptoms. This may be due to abnormal tracking, or may be idiopathic. The Outerbridge arthroscopic classification is widely used to define the severity of chondral damage: stage I, softening; stage II, fissures; stage III, crabmeat changes and stage IV, exposed subchondral bone.

With the exception of acute fracture, patella dislocation with osteochondral fragments and complete tendon disruption, most patellofemoral disorders are treated conservatively. This may include rest, non-steroidal anti-inflammatory agents, physical therapy, icing and/or ultrasound treatment. A more aggressive approach including early surgical intervention may be undertaken with the elite athlete where an optimal outcome and more rapid return to play may be desirable [6].

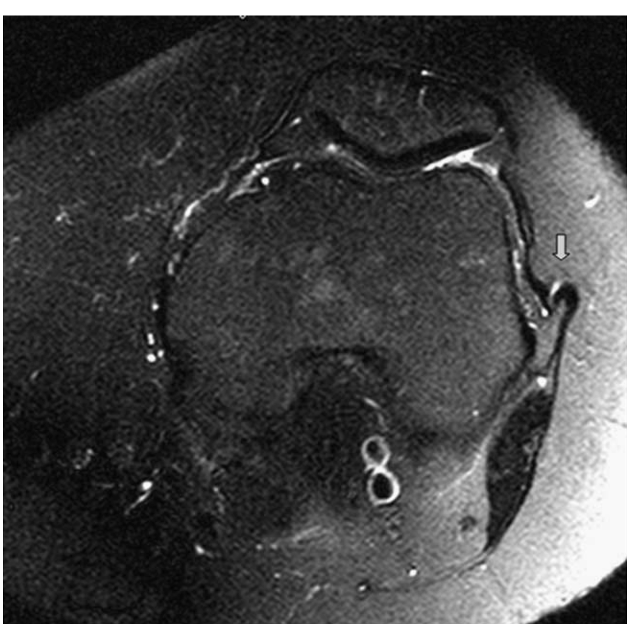


Fig. 5. Axial T2-weighted fast-saturated image shows a fold in the lateral patellar retinaculum with a small interruption of the fibers (arrow head).

3. Trauma

3.1. Patella fracture

The mechanism of patellar fracture is usually a direct blow to the anterior knee. Clinically, the inability to extend the knee and a palpable defect indicate incompetence of the extensor mechanism. The fractures may be transverse, vertical or comminuted. A separation more than 3 mm or an articular step-off of more than 2 mm indicates significant displacement that requires open reduction and internal fixation to re-establish the articular surface. This can be accomplished using tension wires, frequently in a figure-of-eight or circular configuration, Kirschner wires and screws (Fig. 1a) [7]. Occasionally, a comminuted fracture will necessitate a partial patellectomy, preserving the largest fragment.

When obtaining MR images on these post-operative knees, attention should be paid to choose a horizontal phase encoding axis to avoid ferromagnetic artifact obscuring the internal

Fig. 6. Lateral radiograph of the knee shows healed partial anterior wedge osteotomy of the tibia with an integrated interposed bone block.

structures (Fig. 1b). Gradient echo images should be entirely avoided. If evaluating for marrow contusion, an inversion recovery sequence should be utilized to avoid field inhomogeneity that can be problematic with fat-saturated sequences (Fig. 1c).

3.2. Patellar and quadriceps tendon rupture

Patellar tendon rupture commonly occurs in an active adult patient, younger than 40 years in age. Previous or chronic patellar tendonitis is considered a risk factor. Not uncommonly, there is an associated avulsion fracture of the inferior pole of the patella. Quadriceps tendon rupture is more common than patellar tendon rupture, and is usually seen in adults over 40 years in age. Patients with end-stage renal disease and mucoid degeneration of the tendon are at increased risk for this injury. In contrast to patellar tendon ruptures, quadriceps tendon tears are most often intratendinous occurring approximately 2 cm above the proximal pole of the patella.

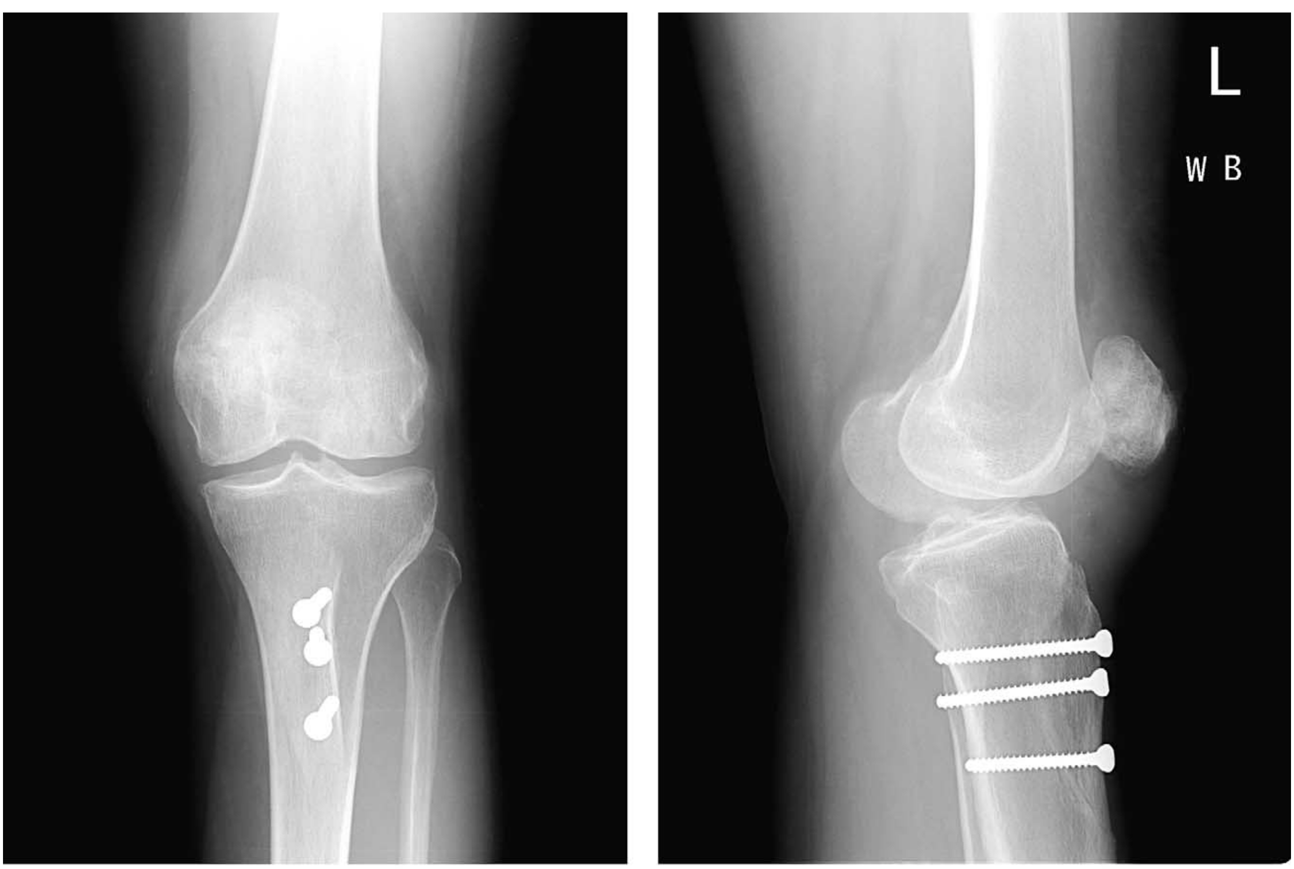
Direct primary tendon repair is usually indicated for patellar tendon rupture (Fig. 2a and b). The surgeon may use non-absorbable sutures woven through the tendon and placed through drill holes in the patella. Suture anchors may also be used. Augmentation with cerclage wires or tape may be performed as well (Fig. 3). Quadriceps tendon ruptures with loss of active knee extension are usually treated with primary surgical end-to-end repair. Again, sutures are woven through the tendon and then tied together for repair. Medial and lateral retinacular tears may also occur in both injuries. Direct repair is accomplished with suture [8,9].

4. Patellofemoral dysplasia

4.1. Lateral patellar facet compression syndrome

This clinical problem is associated with a congenitally tight lateral retinaculum and a lateral tilt of the patella that augments the “natural” lateral pull forces exerted by the extensor apparatus. The tight lateral retinaculum results in decreased patellar mobility.

Occasionally, these individuals will benefit from a lateral retinacular release. This procedure is performed arthroscopically, and may be accompanied by tightening of the medial structures (medial reefing) [10]. As with all arthroscopic procedures, scarring may be seen in Hoffa’s fat pad (Fig. 4) [11]. The site of surgical lateral patellar retinaculum transsection is often not seen on MRI, as it may be small or healed with



(A) (B)

Fig. 7. (A) AP radiograph of the knee with three screws over the osteotomy site of the tibial tuberosity. (B) Lateral projection shows the location of the screws over the tibial tuberosity and thickening of the patellar tendon.

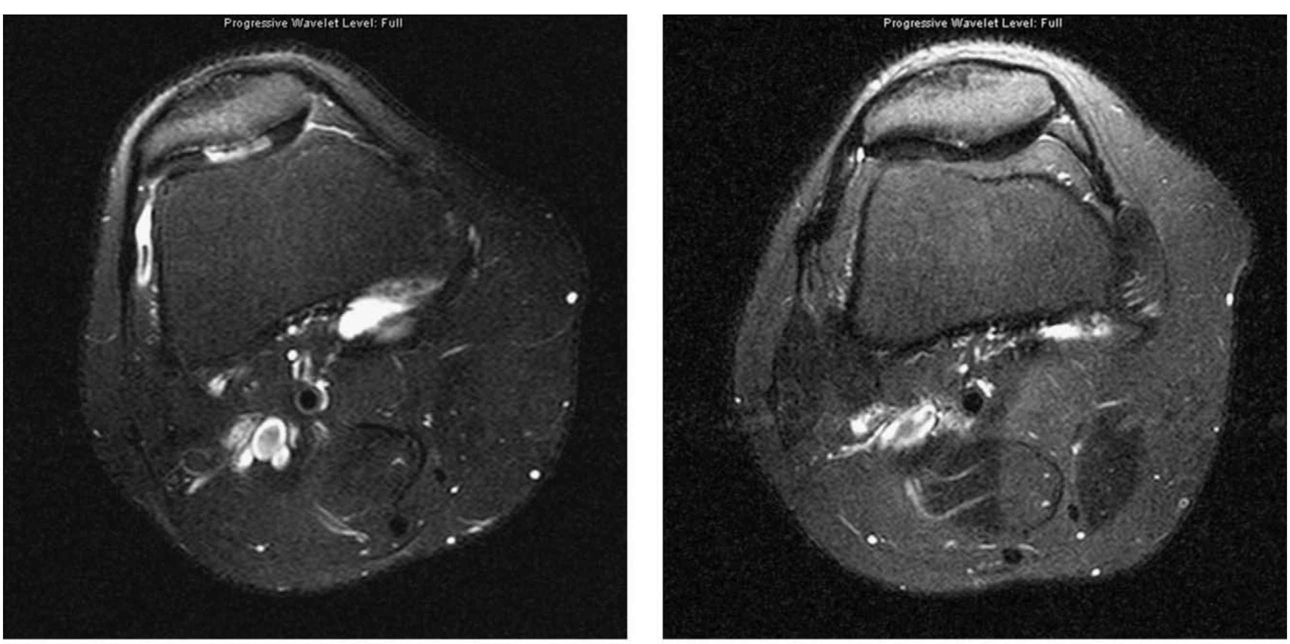
Fig. 8. Lateral portable intraoperative radiograph in a skeletally immature patient shows two screws overlying the patella.

fibrous tissue (Fig. 5). Occasionally, a focal thickening or suture artifact may be encountered.

4.2. Recurrent patellar dislocation or subluxation

Patellar instability is a multifactorial problem. Many feel that a combination of a shallow intercondylar fossa and patellar incongruence is the main causative factor [12]. Femoral anteversion, genu valgum and a pronated foot may exacerbate the symptoms, especially in adolescents [5].

Most frequently, extensive rehabilitation is curative. Surgical intervention may, however, be considered in recalcitrant cases. Numerous surgical procedures have been described. An acute first-time patella dislocation may be treated with arthroscopic elevation and debridement, along with acute repair of the medial patellofemoral ligament. Many surgical options are available for recurrent patella dislocations including reconstruction of the medial patellofemoral ligament, and distal realignment procedures. Distal realignment procedures involve elevation and/or medial placement of the tibial tuberosity, with the objective to decrease the “natural” lateral or backwards pull of the patella. The procedure first described by Maquet serves to decrease the posterior pull of the patella and the patellofemoral contact pressure. The tibial tuberosity is elevated 1–2 cm by an incomplete wedge osteotomy along the anterior aspect of the tibia that includes the tibial tuberosity at the insertion site of the patellar tendon. A bone block is then placed in the osteotomy site to displace this loosened bone wedge anteriorly (Fig. 6) [13]. The Ellmslie-Trillat procedure consists of a complete osteotomy of the



(A) (B)

Fig. 9. (A) Axial fat-saturated T2-weighted image shows the full-thickness apical cartilage defect of the patella. Transferred osteochondral plugs were used to repair this site. (B) Same sequence shows the repaired site after a year, with healed and integrated bone plug. There is only a subtle irregularity of the cartilage surface appreciated.

tibial tuberosity at its base and medial screw fixation (Fig. 7) [14,15]. The Fulkerson method combines these two procedures, and involves both elevation and medial displacement of the tibial tuberosity [16,17].

4.3. Patellar height abnormality

Congenital or acquired patella alta (high) or baja (low) may be associated with patellar instability. The abnormally short or long patella tendon may result in an abnormal articulation between the patella and the intercondylar sulcus, constraining the patella's normal gliding movements [18]. Surgical correction is extremely rare but may involve transsection of the tendon with either shortening or lengthening and possible augmentation with tapes or wires.

5. Chondromalacia patellae

Chondromalacia patellae may occur with all of the above clinical entities as described above. Acute osteochondral injuries usually occur as a result of rotational forces from direct trauma. Debridement with or without chondroplasty is undertaken for symptomatic lesions. A displaced osteochondral fragment can usually be replaced in the bone bed and secured with screws or absorbable pins. Isolated full-thickness cartilage defects may be treated with autologous cultured chondrocyte implantation or osteochondral autograft or allograft [19,20].

Radiographs following cartilage repair may show the pins prior to resorption (Fig. 8). Follow-up MRI may be performed to evaluate the integrity of transferred bone plugs. Choice of optimal sequences to image the patellofemoral joint component is crucial. Comparison with prior preoperative MRI is imperative for assessment of healing (Fig. 9).

6. Summary

A radiologist in a practice with a large orthopedic referral pool may encounter postoperative imaging of patients who have undergone surgical repair of the extensor mechanism. It is helpful for the radiologist to be familiar with the procedures to correctly evaluate the imaging material.

Radiographs may show screws, wires and Kirschner wire fixation for patellar fracture reduction or augmentation. Cortical screws along with healing osteotomy sites may be seen with distal realignment procedures. Suture anchors may be used in patellofemoral ligament reconstructions or repairs.

MRI sequencing needs to be adjusted to avoid ferromagnetic artifact from hardware obscuring the area of interest. Comparison with preoperative imaging studies is most valuable.

References

[1] Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain. Part II. Differential diagnosis. Am Fam Physician 2003;68(5):917–22.
[2] Fulkerson JP. Diagnosis and treatment of patients with patellofemoral pain. Am J Sports Med 2002;30(3):447–56.
[3] Boden BP, Pearsal AW, Garrett Jr WE, Feagin Jr JA. Patellofemoral instability: evaluation and management. J Am Acad Orthop Surg 1997;5(1):47–57.
[4] Kaufmann P, Bose P, Preacher A. New insights into the soft-tissue anatomy anterior to the patella. Lancet 2004;363(9409):586.
[5] Spritzer CE. "Slip sliding away": patellofemoral dislocation and tracking. Magn Reson Imaging Clin N Am 2000;8(2):299–330.
[6] Fithian DC, Paxton EW, Cohen AB. Indications in the treatment of patellar instability. J Knee Surg 2004;17(1):47–56.
[7] Berg EE. Open reduction internal fixation of displaced transverse patella fractures with figure-eight wiring through parallel cannulated compression screws. J Orthop Trauma 1997;11(8):573–6.
[8] Wu CC, Tai CL, Chen WJ. Patellar band wiring: a revised technique. Arch Orthop Trauma Surg 2001;121(1–2):12–6.
[9] Kasten P, Schewe B, Maurer F, Gosling T, Krettek C, Weise K. Rupture of the patellar tendon: a review of 68 cases and a retrospective study of 29 ruptures comparing two methods of augmentation. Arch Orthop Trauma Surg 2001;121(10):578–82.
[10] Calpur OU, Ozcan M, Gurbuz H, Turan FN. Full arthroscopic lateral retinacular release with hook knife and quadriceps pressure-pull test: long-term follow-up. Knee Surg Sports Traumatol Arthrosc 2004 [Epub ahead of print].
[11] Saddik D, McNally EG, Richardson M. MRI of Hoffa's fat pad. Skeletal Radiol 2004;33:433–4.
[12] Davies AP, Costa ML, Shepstone L, Glasgow MM, Donnell S, Donnell ST. The sulcus angle and malalignment of the extensor mechanism of the knee. J Bone Joint Surg Br 2000;82(8):1162–6.
[13] Jenny JY, Sader Z, Henry A, Jenny G, Jaeger JH. Elevation of the tibial tubercle for patellofemoral pain syndrome: an 8- to 15-year follow-up. Knee Surg Sports Traumatol Arthrosc 1996;4(2):92–6.
[14] Nakagawa K, Wada Y, Minamide M, Tsuchiya A, Moriya H. Deterioration of long-term clinical results after the Elmslie-Trillat procedure for dislocation of the patella. J Bone Joint Surg B 2002;84(6):861–4.
[15] Kumar A, Jones S, Bickerstaff DR, Smith TW. Functional evaluation of the modified Elmslie-Trillat procedure for patellofemoral dysfunction. Knee 2001;8(4):287–92.
[16] Maracci M, Zaffagnini S, Lo Presti M, Vascellari A, Iacono F, Russo A. Treatment of chronic patellar dislocation with a modified Elmslie-Trillat procedure. Arch Orthop Trauma Surg 2004;124(4):250–7.
[17] Fulkerson JP. Operative management of patellofemoral pain. Ann Chir Gynaecol 1991;80(2):224–9.
[18] Shabshin N, Schweitzer ME, Morrison WB, Parker L. MRI criteria for patella alta and baja. Skeletal Radiol 2004;33(8):445–50.
[19] Nomura E, Inoue M, Kurimura M. Chondral and osteochondral injuries associated with acute patellar dislocation. Arthroscopy 2003;19(7):717–21.
[20] Hangody L, Feczko P, Bartha L, Bodo G, Kish G. Mosaicplasty for the treatment of articular defects of the knee and ankle. Clin Orthop 2001;391(Suppl.):328–36.