Debridement

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Background

The rising prevalence of symptomatic cartilage lesions in the United States has resulted in numerous surgical procedures that provide pain relief, decreased inflammation, and improved overall joint functionality. The most effective treatment for articular cartilage defects is a topic of controversy, but arthroscopic debridement is widely used as a first step in surgical management after nonsurgical interventions have proven unsuccessful [1–3]. Debridement techniques aim to remove and stabilize mobile or delaminated articular cartilage flaps, loose bodies or debris, unstable torn menisci, and thickened, hypertrophic synovium that may cause joint pain and inflammation [4, 5]. The primary goal is to alleviate painful, mechanical symptoms or to aid in preparation for more complex, staged procedures to address more significant underlying chondral pathology. In addition to chondroplasty, debridement may include synovectomy and/or meniscectomy.

The two most common forms of chondral debridement are mechanical and thermal. Mechanical debridement may be accomplished with the aid of an oscillating shaver, arthroscopic biters or graspers, and curettes. Thermal debridement may be used with both mono- and bipolar radiofrequency devices. An arthroscopic bovie may be used to smooth rough chondral edges or flaps and soften transition zones. Previous studies have shown potentially harmful effects to chondrocytes at the cellular level, however, and as such, standard radiofrequency devices should be used with caution [6, 7]. New devices that decrease the overall temperature with the joint have shown some potential benefit, however, and may even have some improvements over mechanical debridement alone [6–8]. Other new techniques incorporating nonthermal ion debridement have been reported to cause no thermal necrosis or chondrocyte death [9]. Further clinical trials and peer-reviewed studies are required, however, before routine use of such devices may be recommended.

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Case Study

A 56-year-old man presented with insidious onset of medial knee pain for several months. The patient experienced activity-related swelling and mechanical symptoms without instability. The patient reported pain scores ranging from 2 to 9 out of 10 and believed his knee function was only 40% of normal. The pain was affecting his ability to sleep, his daily life activities, and his quality of life. Imaging and physical examination were consistent with a degenerative medial meniscus tear. Aspiration, cortisone injections, compression sleeve, and physical therapy were trialed without prolonged success. During arthroscopy, a hypertrophic anterior fat pad and plica sheet and shelf were excised. A suprapatellar synovectomy and limited lateral synovectomy were also performed. Direct visualization of the medial meniscus determined that the tear was unrepairable, and a biter along with a shaver was used to remove the damaged portion in the white-white zone. Loose and unstable chondral flaps on the medial femoral condyle were also identified. This region was treated with chondroplasty. Six months following the procedure, the patient returned to full activity without pain, effusion, or instability (Fig. 15.1 a–c).

Classification

Numerous classification systems have been evaluated to describe the depth, character, and morphology of cartilage lesions [10, 11]. The Outerbridge classification describes the extent and overall size of the lesion and is still frequently used in the setting of degenerative joint disease and its related cartilage lesions (Table 15.1) [10]. The International Cartilage Repair System (ICRS) also incorporates the depth of the lesion and is particularly useful in the setting of potential cartilage repair or restoration procedures (Table 15.2) [11]. Various other classification systems have also been described, but regardless of the system employed, classifying and grading the cartilage can help guide treatment planning.

Indications

The benefit of knee arthroscopic debridement has been demonstrated by many previous studies; however, there is a growing amount of research suggesting that indications for debridement alone should be limited [2–4, 8]. Arthroscopic debridement can be considered as a first-line treatment for small chondral lesions in high-demand patients and large lesions in low-demand patients who have failed extensive conservative measures. In particular, patients with mechanical symptoms, with associated joint pain and swelling and evidence of chondral loose flaps or loose bodies, may benefit from debridement alone. The goal for arthroscopic debridement is to produce stable and smooth articular cartilage surfaces, decrease inflammation, and improve mechanical function. Debridement does not stimulate articular cartilage repair, however, and as such may be incorporated as part of a staging procedure in patients with larger chondral lesions

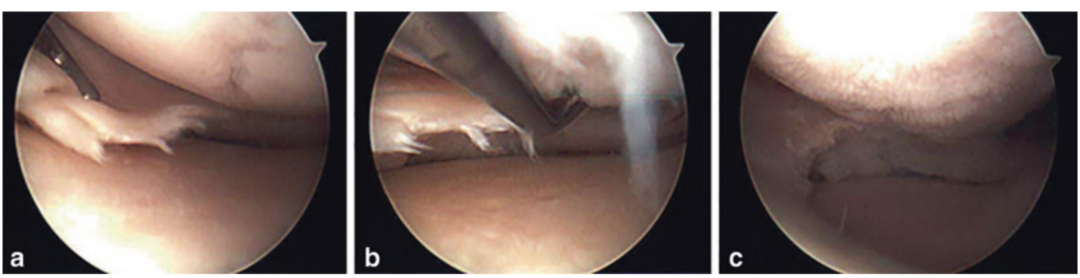

Fig. 15.1 (**a**–**c**) Arthroscopic images showing a defect that required debridement

Table 15.1 Outerbridge classification system

Grade	Description of cartilage defect
0	Normal cartilage
1	Softening and swelling of cartilage
2	Fragmentation and fissuring in an area half an inch or less in diameter
3	Fragmentation and fissuring in an area greater than half an inch in diameter
4	Erosion of cartilage down to the bone

Based on data from Ref. [10]

Table 15.2 ICRS classification system

Grade	Description of cartilage defect
0	Normal cartilage
1a	Intact surface, fibrillation, or slight softening
1b	Intact surface, additional superficial lacerations, and fissures
2	Defects extend deeper than type 1 but with less than 50% of cartilage thickness
3a	Defects extend more than 50% of cartilage thickness but not to calcified layer
3b	Defects extend more than 50% of cartilage thickness and to calcified layer
3c	Defects extend to but not through subchondral bone
3d	Includes bulging of the cartilage around the lesion (cartilage blister)
4a	Full-thickness cartilage defect with extension into subchondral bone
4b	Penetration of subchondral bone across full diameter of the defect

Based on data from Ref. [11]

who require further procedures, such as autologous chondrocyte implantation or osteochondral transplantation. Debridement alone is contraindicated as the primary treatment of patients with advanced chondral disease and joint space narrowing (i.e., extensive osteoarthrosis).

Surgical Techniques

Mechanical Debridement

After standard arthroscopic setup and diagnostic evaluation, the areas of pathology may be probed to identify size, depth, and extent. Synovial hypertrophy or large plica bands may be identified within the medial and lateral . Chondral defects and corresponding areas of delamination should be closely evaluated (Fig. 15.2). Mechanical debridement uses oscillating shavers, biters, curettes, gouges, and other tools to debride any intra-articular pathology necessary. Specifically, loose cartilage flaps are debrided back to a stable rim with a shaver or biter (Fig. 15.3). A key differentiation in the type of debridement performed should be made based on the extent of the cartilage lesion. Grade 2 or 3 lesions should have loose flaps debrided back to smooth edges to prevent any further mechanical irritation or symptoms, but the subchondral bone should not be exposed. Extensive grade 3 or grade 4 (full-thickness) lesions should have well-defined, vertical walls created at the transition zone from healthy cartilage to damaged cartilage (Fig. 15.4). Curettes and gouges may be used to create stable vertical walls, as this has been shown to result in less defect expansion with time [12].

Collateral cell death from mechanical debridement is a topic of controversy. Edwards et al., in two separate studies, have found that mechanical debridement has no statistically significant difference in chondrocyte death or viability from the control group [5, 13]. However, others theorize that mechanical debridement can cause collateral damage and cell death and should therefore be used judiciously [14, 15]. Regardless, care should be taken to avoid removing healthy cartilage and limiting the stable tissue border to the minimum possible depth – this limits the exposure of bare bone and reduces the risk of progressive osteoarthritis.

Thermal Debridement

Thermal debridement with radiofrequency devices can be separated into two categories: monopolar and bipolar. Monopolar radiofrequency energy has two means of passing from the probe to the ground plate on the skin. Energy either passes through the cartilaginous surface and subchondral bone or through the irrigation solution and joint capsule [5, 16]. Bipolar radiofrequency energy, on the other hand, passes from the positive pole, through the irrigation fluid, to

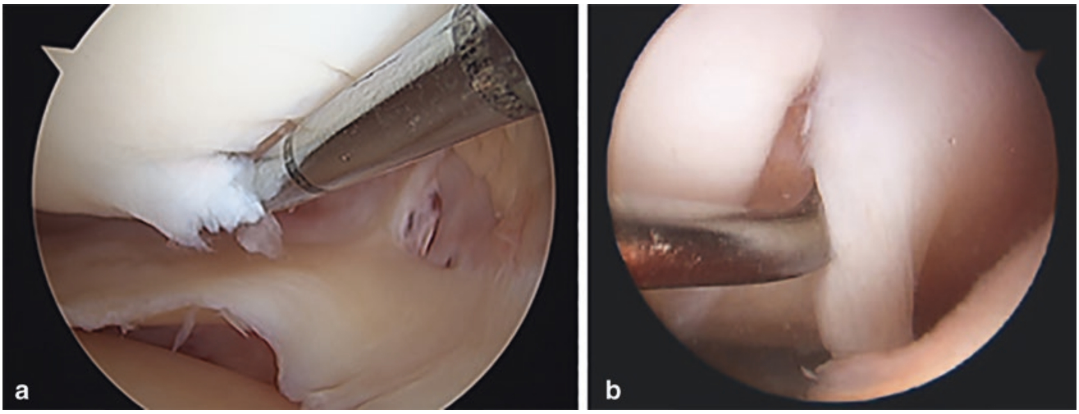

Fig. 15.2 (**a**–**b**) Arthroscopic images depicting delaminated cartilage flaps

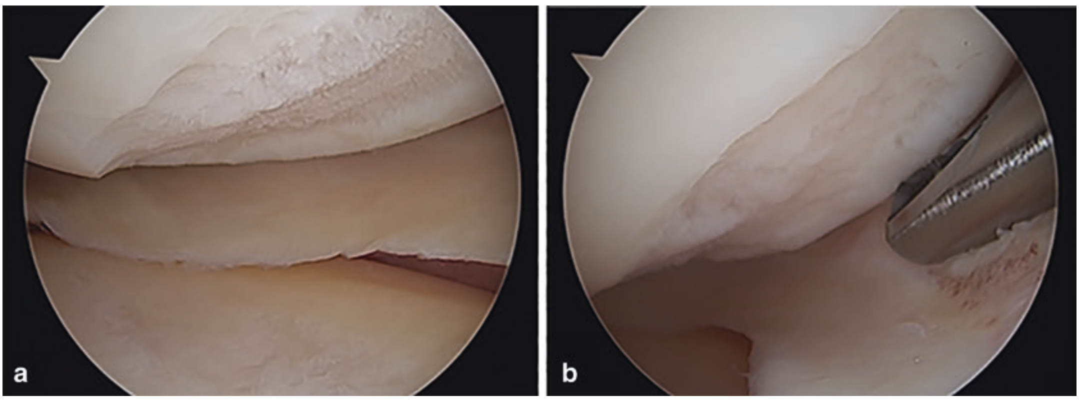

Fig. 15.3 (**a**–**b**) Arthroscopic image depicting debridement of chondral flap with a mechanical shaver to smooth transition edges

the negative pole of the probe [5, 16]. Both methods use thermal energy to contour the articular surface.

Correct usage of radiofrequency devices may increase precision of debridement and creates a smoother articular surface than mechanical debridement [17]. However, safety and efficacy of these instruments are areas of active investigation. Lu et al. have performed several studies that recommend modest use of radiofrequency energy to avoid potential complications of iatrogenic collateral chondrocyte damage and decreased viability [5, 9, 18–20]. Caution must be used when working with radiofrequency probes due to the high temperatures caused by energy propagation through the irrigation fluid. Typically, the fluid temperature at the probe head should be limited to less than approximately 45 °C, above which cartilage damage may occur [21]. Failure to exert caution may result in unintended contouring of tissue, collateral chondrocyte damage, tissue necrosis, and corruption of superficial and transitional zones.

Nonthermal Debridement

Non-ablative radiofrequency devices serve as hybrids between mechanical and thermal debridement. These devices use protective housing to minimize direct electrode contact with the

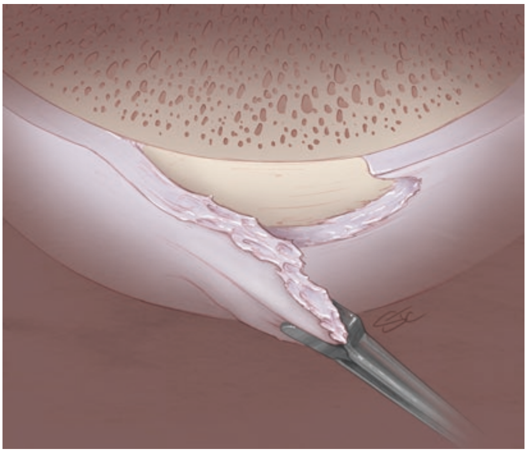

Fig. 15.4 Illustration of debridement of a chondral flap with an arthroscopic biter. (Courtesy of the University of Missouri School of Medicine)

treatment site, avoiding unnecessary energy propagation through irrigation fluid that can result in collateral chondrocyte damage, tissue necrosis, and corruption of the superficial and transitional zones [17]. The ions created from the probe only debride pathologic cartilage because healthy cartilage is protected by a superficial phospholipid bilayer. Thus, nonthermal devices can be successful in preserving superficial and transitional zone integrity without sacrificing effectiveness in smoothing the articular surface or debriding the joint. Ganguly et al. theorize that eliminating iatrogenic cartilage damage may expand the role and efficacy of debridement interventions, making nonthermal debridement a promising future treatment option [17].

Methods of Debridement

Chondroplasty

Chondroplasty is a long-standing debridement technique used to alleviate symptoms related to damaged articular surfaces. The goal is to reduce the volume of cartilage fragmentation, decrease the number of loose bodies, and create stable vertical walls surrounding the defect. When compared to beveled walls, vertical walls resulted in faster repair of the treatment site (Fig. 15.5) [22]. Chondroplasty most often focuses on loose chondral flaps that have delaminated from the subchondral bone. The cartilage should be kept grossly intact when possible. In debriding the lesions, care should be taken to avoid removing healthy cartilage and limiting the stable tissue border to the minimum possible depth, thus limiting the exposure of bare bone and potentially contributing to the development of osteoarthritis. Following chondroplasty, there may remain a full-thickness lesion that would require further interventions, such as marrow stimulation or more complex cartilage restoration procedures.

Abrasion Arthroplasty

Arthroscopic abrasion arthroplasty is an adaption of the Magnusson knee debridement procedure [23]. Similar to other forms of debridement, abrasion arthroplasty is considered a palliative procedure rather than a curative treatment. The procedure involves using curettes or a burr to remove the deep calcified layer of cartilage and expose healthy, vascular tissue (Fig. 15.5). The abrasion should be limited to the superficial regions of exposed subchondral bone [24]. The goal is to create increased vascularity and a uniform bleeding surface that serves as the first step of the healing process. This initiates portions of the healing cascade, which can result in the production of fibrocartilage at the affected area [24]. The benefits of abrasion arthroplasty are that it is minimally invasive and does not violate the subchondral plate, thus minimizing the risk of bony injury or edema that may result from marrow stimulation procedures. Indications should be restricted to small, well-contained cartilage lesions because this technique is a salvage procedure, unproven to serve as a primary treatment for larger lesions that may require more complex procedures [24].

Intra-articular Debridement

Intra-articular debridement, including plica resections or synovectomy procedures, is often

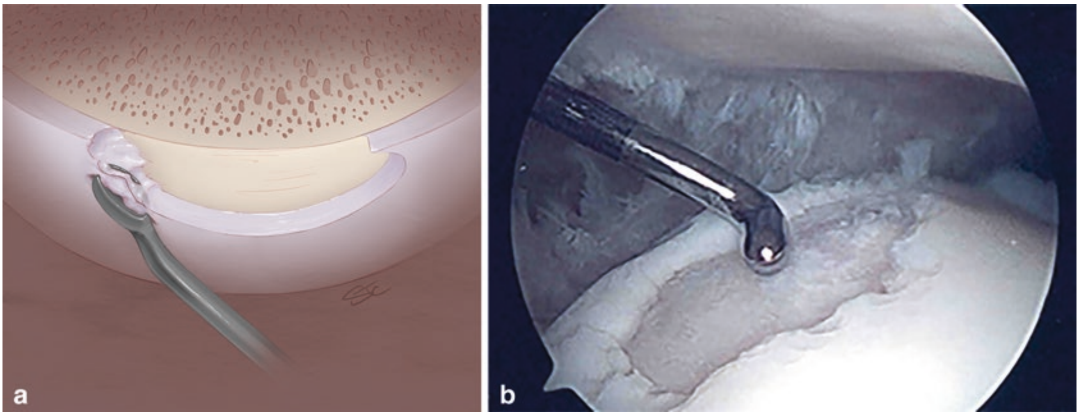

Fig. 15.5 (**a**) Illustration depicting debridement of a chondral lesion with a curette, creating stable, vertical walls. (**b**) Arthroscopic image depicting stable cartilage walls after debridement. A: (Courtesy of the University of Missouri School of Medicine)

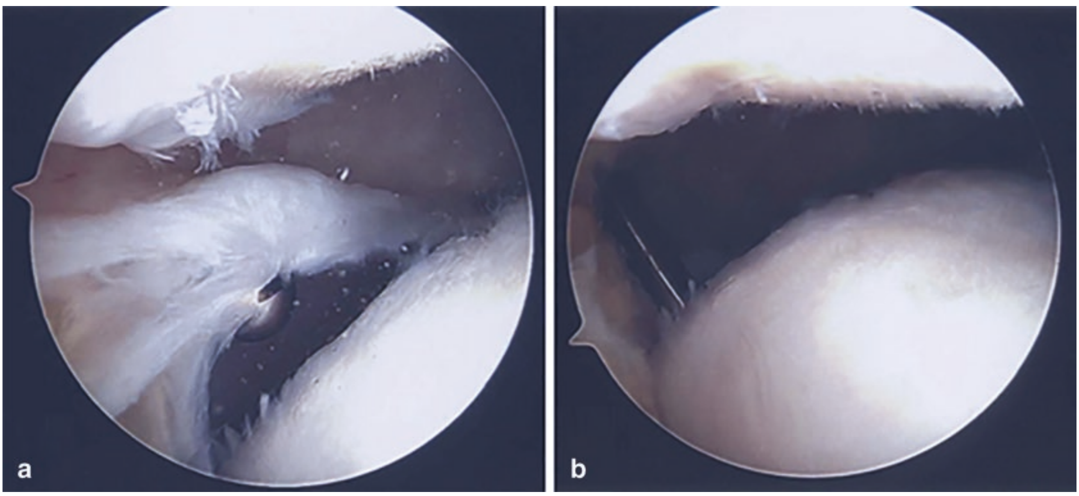

Fig. 15.6 (**a**) Arthroscopic image depicting a hypertrophic synovial band over the medial femoral condyle. (**b**) Arthroscopic image of the knee after removal of the synovial band with an arthroscopic shaver and biter

performed in cases of inflammatory conditions, or when other treatments have failed, or as concurrent procedures when addressing chondral pathology [25–27]. The medial and lateral plicae are normal anatomic structure folds in the synovium of the knee joint. They may become thickened and hypertrophied, however, in the presence of inflammation or other pathology within the joint. This form of synovial hypertrophy frequently accompanies long-standing chondral lesions, chondromalacia, or early osteoarthritis. Medial abrasion syndrome occurs when the synovial hypertrophy is extensive and begins to erode the articular cartilage of the medial femoral condyle, creating a "rub lesion" over the condyle (Fig. 15.6) [27]. This may also result in symptomatic mechanical snapping or popping within the knee. Thorough debridement of this hypertrophied tissue with the use of oscillating shavers, biters, and radiofrequency devices can remove mechanical symptoms and decrease the overall inflammatory burden within the joint.

This procedure is usually performed arthroscopically and aims to reduce synovitis from the affected joint to improve mechanical function. Meniscal debridement can also be performed as a concomitant procedure and should be reserved for degenerative tears in avascular regions or tears which are unresponsive to other treatments [6]. Various debridement tools are used to smooth and contour the unstable regions with special care to minimize the amount of fibrocartilage removed [28]. The debridement is often initiated with a biter, and a shaver is used to remove fragments of meniscus. Suction pulls frayed tissue into the shaver without affecting healthy meniscus. The goal is to contour the treatment area with a smooth transition zone back to healthy tissue.

Rehabilitation

Following debridement procedures, patients should be enrolled in a rehabilitation program under the direction of a physical therapist or athletic trainer. The goal of rehabilitation is to optimize outcomes by restoring range of motion and improving strength and neuromuscular control. Factors such as controlling pain, normalizing gait, monitoring effusion, and regaining flexibility (i.e., patella mobility, terminal extension) should also be emphasized early. A "core to floor" strengthening program is important for later phases of rehabilitation. Guidelines should be tailored based on patient progression, but there are generally few restrictions placed on patients in most cases. For patients with larger chondral lesions, counseling can be beneficial for them to understand the potential for a slow recovery and the possibility of further future procedures. Factors such as age, weight, concurrent pathology, pre-injury status, and rehabilitation compliance may play a role in the return-to-sport or return-to-activity date.

Results

The debate surrounding the efficacy of various debridement techniques is ongoing. One of the confounding factors in studying the efficacy of various types of debridement is that they are often performed along with other surgical interventions to address concurrent pathologies. The studies included have varying levels of evidence, with some randomized controlled trials comparing different debridement procedures and some case series (level of evidence 3 and 4). Table 15.3 lists the results of several debridement outcome studies.

Table 15.3 Outcomes after debridement procedures

Reference	Type of study	Patients	Follow-up (mean)	Outcomes
Spahn et al. [12]	RCT	30	48 months	bRFE has better midterm results than classic mechanical debridement
Anderson et al. [29]	Case series	86	31.5 months	Chondroplasty is beneficial in the absence of concurrent pathology
Owens et al. [30]	RCT	39	24 months	bRFE has better clinical outcomes for patellar grade 2 and 3 lesions than MSD
Barber et al. [31]	RCT	60	19 months	Both mRFE and MSD groups had significant improvement in pain and functional outcomes. No difference when mRFE was used as an adjunct to MSD compared to MSD alone
Spahn et al. [32]	RCT	60	12 months	RFE-based chondroplasty had significant better outcome scores than MSD-based chondroplasty for medial femoral condyle lesions with partial meniscectomy
Stein et al. [33]	RCT	146	12 months	MSD had better outcome scores when compared to MSD with RFE

RCT randomized controlled trial, *bRFE* bipolar radiofrequency energy, *mRFE* monopolar radiofrequency energy, *MSD* mechanical shaver debridement

Conclusion

Chondral debridement is a limited goal treatment option for symptomatic chondral lesions of the knee that have failed conservative management. The goal of surgery is to address mechanical symptoms related to unstable chondral lesions. Debridement may be considered as a low-cost, first-line treatment option for small lesions (<1–2 cm^2) in high-demand patients and larger lesions (>2 cm^2) in low-demand patients. It is also performed during staging arthroscopy to help plan for definitive cartilage repair (i.e., autologous cultured chondrocytes on porcine collagen membrane (MACI®), or osteochondral allografts (OCA)). Debridement should be combined with treatment of concomitant intra-articular pathology (i.e., synovitis, meniscal tear) to maximize outcome.

References

1. Falah M, Nierenberg G, Soudry M, Hayden M, Volpin G. Treatment of articular cartilage lesions of the knee. Int Orthop. 2010;34(5):621–30.
2. Day B. The indications for arthroscopic debridement for osteoarthritis of the knee. Orthop Clin North Am. 2005;36(4):413–7.
3. Laupattarakasem W, Laopaiboon M, Laupattarakasem P, Sumananont C. Arthroscopic debridement for knee osteoarthritis. Cochrane Database Syst Rev. 2008;1:CD005118.
4. Moseley JB, O'Malley K, Petersen NJ, et al. A controlled trial of arthroscopic surgery for osteoarthritis of the knee. N Engl J Med. 2002;347(2):81–8.
5. Edwards RB, Lu Y, Uthamanthil RK, et al. Comparison of mechanical debridement and radiofrequency energy for chondroplasty in an in vivo equine model of partial thickness cartilage injury. Osteoarthr Cartil. 2007;15(2):169–78.
6. Ward BD, Lubowitz JH. Basic knee arthroscopy Part 4: chondroplasty, meniscectomy, and cruciate ligament evaluation. Arthrosc Tech. 2013;2(4):e507–8.
7. Voloshin I, Morse KR, Allred CD, Bissell SA, Maloney MD, DeHaven KE. Arthroscopic evaluation of radiofrequency chondroplasty of the knee. Am J Sports Med. 2007;35(10):1702–7.
8. Fond J, Rodin D, Ahmad S, Nirschl RP. Arthroscopic debridement for the treatment of osteoarthritis of the knee: 2- and 5-year results. Arthroscopy. 2002;18(8):829–34.
9. Uthamanthil RK, Edwards RB, Lu Y, Manley PA, Athanasiou KA, Markel MD. In vivo study on the short-term effect of radiofrequency energy on chondromalacic patellar cartilage and its correlation with calcified cartilage pathology in an equine model. J Orthop Res. 2006;24(4):716–24.
10. Outerbridge RE. The etiology of chondromalacia patellae. J Bone Joint Surg Br. 1961;43-B:752–7.
11. Mainil-Varlet P, Aigner T, Bullough P, et al. Histological assessment of cartilage repair: a report by the histology endpoint Committee of the International Cartilage Repair Society (ICRS). J Bone Joint Surg Am. 2003;85-A(Suppl 2):45–57.
12. Spahn G, Klinger HM, Mückley T, Hofmann GO. Four-year results from a randomized controlled study of knee chondroplasty with concomitant medial meniscectomy: mechanical debridement versus radiofrequency chondroplasty. Arthroscopy. 2010;26(9):S73–80.
13. Edwards RB, Lu Y, Cole BJ, Muir P, Markel MD. Comparison of radiofrequency treatment and mechancial debridement of fibrillated cartilage in an equine model. Vet Comp Orthop Traumatol. 2008;21(4):41–8.
14. Arnoczky SP (Moderator). Is there a role for radiofrequency-based ablation in the treatment of chondral lesions? Am J Orthop. 2005;34(8 Suppl):3–15.
15. Lotto ML, Wright EJ, Appleby D, Zelicof SB, Lemos MJ, Lubowitz JH. *Ex vivo* comparison of mechanical versus thermal chondroplasty: assessment of tissue effect at the surgical endpoint. Arthroscopy. 2008;24(4):410–5.
16. Rocco P, Lorenzo DB, Guglielmo T, Michele P, Nicola M, Vincenzo D. Radiofrequency energy in the arthroscopic treatment of knee chondral lesions: a systematic review. Br Med Bull. 2016;117(1):149–56.
17. Ganguly K, McRury ID, Goodwin PM, Morgan RE, Augé Ii WK. Histopomorphic evaluation of radiofrequency mediated débridement chondroplasty. Open Orthop J. 2010;4:211–20.
18. Lu Y, Edwards RB, Nho S, Heiner JP, Cole BJ, Markel MD. Thermal chondroplasty with bipolar and monopolar radiofrequency energy: effect of treatment time on chondrocyte death and surface contouring. Arthroscopy. 2002;18(7):779–88.
19. Edwards RB 3rd, Lu Y, Nho S, Cole BJ, Markel MD. Thermal chondroplasty of chondromalacic human cartilage. An ex vivo comparison of bipolar and monopolar radiofrequency devices. Am J Sports Med. 2002;30(1):90–7.
20. Lotto ML, Lu Y, Mitchell ME, Wright EJ, Lubowitz JH, Markel MD. An ex vivo thermal chondroplasty model: the association of a char-like layer and underlying cell death. Arthroscopy. 2006;22(11):1159–62.
21. Mead RN, Ryu J, Liu S, Ge D, Lucas J, Savoie FH 3rd, You Z. Supraphysiologic temperature enhances cytotoxic effects of bupivacaine on bovine articular chondrocytes in an in vitro study. Arthroscopy. 2012;28(3):397–404.

22. Rudd RG, Visco DM, Kincaid SA, Cantwell HD. The effects of beveling the margins of articular cartilage defects in immature dogs. Vet Surg. 1987;16(5):378–83.
23. Magnuson PB. Technic of debridement of the knee joint for arthritis. Surg Clin North Am. 1946;26:249–66.
24. Johnson L. Arthroscopic abrasion arthroplasty: a review. Clin Orthop Relat Res. 2001;391:306–17.
25. Prejbeanu R, Poenaru DV, Balanescu AD, Mioc ML. Long term results after arthroscopic resection of medial plicae of the knee-a prospective study. Int Orthop. 2017;41(1):121–5.
26. Weckstrom M, Niva MH, Lamminen A, Mattila VM, Pihlajamaki HK. Arthroscopic resection of medial plica of the knee in young adults. Knee. 2010;17(2):103–7.
27. Lyu SR, Lee CC, Hsu CC. Medial abrasion syndrome: a neglected cause of knee pain in middle and old age. Medicine. 2015;94(16):e736. Erratum: 2015;94(21):1.
28. Park IH, Kim SJ, Choi DH, Lee SC, Park HY, Jung KA. Meniscectomy of horizontal tears of the lateral meniscus anterior horn using the joystick technique. Knee. 2014;21(1):315–7.
29. Anderson DE, Rose MB, Wille AJ, Wiedrick J, Crawford DC. Arthroscopic mechanical chondroplasty of the knee is beneficial for treatment of focal cartilage lesions in the absence of concurrent pathology. Orthop J Sport Med. 2017;5(5):2325967117707213.
30. Owens BD, Stickles BJ, Balikian P, Busconi BD, Fu F, Eyre D. Prospective analysis of radiofrequency versus mechanical debridement of isolated patellar chondral lesions. Arthroscopy. 2002;18(2):151–5.
31. Barber FA, Iwasko NG, Gilley JA, DeLee JC, Wright JC, Markel MD. Treatment of Grade III femoral chondral lesions: mechanical chondroplasty versus monopolar radiofrequency probe. Arthroscopy. 2006;22(12):1312–7.
32. Spahn G, Kahl E, Mückley T, Hofmann GO, Klinger HM. Arthroscopic knee chondroplasty using a bipolar radiofrequency-based device compared to mechanical shaver: results of a prospective, randomized, controlled study. Knee Surg Sport Traumatol Arthrosc. 2008;16(6):565–73.
33. Stein DT, Ricciardi CA, Viehe T. The effectiveness of the use of electrocautery with chondroplasty in treating chondromalacic lesions: a randomized prospective study. Arthroscopy. 2002;18(2):190–3.