Thesis

Evaluation of Efficacy of Surgical Management for Treatment of Chondral Defects of the Knee in Adults

Shaunak Patwardhan[1],
Parag Sancheti[1],
Kailas Patil[1],
Sunny Gugale[1],
Sahil Sanghavi[1],
Yogesh Sisodia[1],
Obaid UL Nisar[1],
Darshan Sonawane[1],
Ashok Shyam[1]

[1]Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India.

Address of Correspondence
Dr. Shaunak Patwardhan,
Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India.
Email : patwardhanshaunak@gmail.com

Abstract

Background: Articular cartilage defects of the femoral condyles cause pain and functional decline; untreated full-thickness lesions predispose to early osteoarthritis. This study compared short-term outcomes after three surgical strategies—arthroscopic microfracture, two-stage autologous chondrocyte implantation (ACI) and single-stage bone marrow aspirate concentrate (BMAC)—for full-thickness femoral condyle defects ≥2.0 cm^2.

Methods: In this prospective single-centre cohort (Oct 2019–Oct 2021) 66 adults meeting inclusion criteria were enrolled; 53 completed one-year follow up. Treatment selection was individualized. Primary outcomes were IKDC and KOOS scores measured preoperatively and at 6 and 12 months. Secondary outcomes included MOCART MRI appearance and complication rates. Standard rehabilitation and statistical analysis were applied.

Results: All three techniques produced clinically meaningful improvements in IKDC and KOOS at one year. Greater gains correlated with younger age, lower BMI and shorter symptom duration. Between-group differences at one year were not statistically significant in this cohort. MRI (available for 23 patients) generally showed defect fill and integration. Complications were few and minor.

Conclusion: Arthroscopic microfracture, single-stage BMAC and two-stage ACI each provided meaningful short-term functional improvement with low complication rates. Individualized technique selection is recommended; longer randomized studies are needed to assess durability.

Keywords: Cartilage defect, Microfracture, Autologous chondrocyte implantation, BMAC, IKDC, KOOS.

Introduction

Articular cartilage is a highly specialized, avascular and aneural tissue with limited intrinsic capacity for repair. Its zonal architecture and sparse cellularity confer excellent load-bearing and low friction properties but hinder meaningful regeneration after full-thickness injury [1]. Full-thickness chondral and osteochondral defects of the femoral condyles frequently produce pain, mechanical symptoms and functional impairment and are encountered commonly at diagnostic arthroscopy of symptomatic knees [2, 3]. Epidemiological series indicate that focal cartilage lesions are prevalent among patients undergoing knee arthroscopy and can produce morbidity comparable to more advanced degenerative disease in selected populations [4, 5]. The aetiology of focal defects is

Dr. Shounk Patwardhan | Dr. Parag Sancheti | Dr. Kailas Patil | Dr. Sunny Gugale | Dr. Sahil Sanghavi | Dr. Yogesh Sisodiya | Dr. Obaid UI Nisar | Dr. Darshan Sonawane | Dr. Ashok Shyam

DOI: https://doi.org/10.13107/jmt.2024.v10.i01.230

heterogeneous — acute trauma, repetitive overload, axial malalignment, meniscal deficiency and ligamentous instability are common contributors — and the lesion characteristics (size, depth, location) together with patient factors (age, activity level, body mass index) largely determine therapeutic choice and prognosis [3, 6].

Surgical approaches for symptomatic full-thickness defects range from palliative arthroscopic debridement to marrow-stimulation techniques (microfracture), osteochondral autograft transfer (OATS/mosaicplasty), two-stage cell-based restorative techniques such as autologous chondrocyte implantation (ACI), and contemporary one-stage biologic augmentations that combine concentrated marrow elements (BMAC) with scaffolds [7, 8]. Microfracture has been widely used for small to moderate defects because it is technically straightforward and cost-effective, but it produces predominantly fibrocartilaginous fill that may be biomechanically inferior to hyaline cartilage [9–11]. ACI and matrix-augmented ACI aim to regenerate hyaline-like tissue through chondrocyte expansion and implantation but require two procedures and greater resource allocation [12–14]. Single-stage BMAC approaches are attractive in resource-constrained settings because they concentrate marrow-derived progenitor cells and growth factors in one operation, but standardisation of preparation and robust long-term comparative evidence remain limited [15–18].

Systematic reviews and meta-analyses demonstrate heterogeneity across studies in patient selection, lesion characteristics and outcome reporting; therefore, firm universal recommendations regarding a single superior technique are difficult to make [6, 19]. This study therefore sought to evaluate short-term functional and radiological outcomes following microfracture, two-stage ACI and single-stage BMAC in a prospective cohort treated at a tertiary orthopaedic centre, with the goal of informing surgeon decision-making in similar clinical and resource settings [20].

Literature overview

Large arthroscopic cohorts and registry data highlight the frequency and clinical burden of focal cartilage lesions [3, 4]. Microfracture has been associated with reliable short-term symptomatic relief, particularly in younger patients with smaller lesions, but durability may decline over time, especially for larger defects [9–11]. Mosaicplasty transfers hyaline cartilage plugs but is constrained by donor site morbidity and size limitations [12]. ACI and matrix-assisted cell therapies have demonstrated favourable medium-term outcomes in many series but at the cost of two-stage procedures and greater expense [13–16]. Contemporary interest centers on single-stage biologic augmentation (eg, BMAC with scaffolds) which offers logistical advantages and encouraging early imaging and functional results, though preparation protocols and long-term data are variable [6, 14, 17, 18]. Systematic reviews emphasise patient selection and lesion characteristics as key determinants of success, supporting individualized treatment planning [6, 19].

Materials and Methods

This prospective single-centre cohort was conducted from October 2019 to October 2021. Adults aged 15–55 years with symptomatic ICRS/Outerbridge grade 4 full-thickness chondral defects of the femoral condyles measuring ≥2.0 cm^2 on MRI or arthroscopic assessment were considered. Patients with advanced degenerative knee disease, systemic metabolic or neoplastic illness, intra-articular fractures, prior ipsilateral major knee surgery or defects <2.0 cm^2 were excluded. Institutional ethics approval and informed consent were obtained for all participants.

Baseline evaluation included a standardized history, physical examination, IKDC and KOOS questionnaires, weight and BMI measurement, plain radiographs and MRI to document lesion size, depth and associated meniscal or ligamentous pathology. Sixty-six consecutive eligible patients were enrolled; surgical strategy selection (microfracture, two-stage ACI or single-stage BMAC) was individualized based on defect size and location, associated pathology, patient preferences and resource considerations. Concomitant meniscal repair or ligament reconstruction was performed when indicated.

Surgical techniques followed standardized protocols. Microfracture was performed arthroscopically with stable borders debrided and multiple perforations into the subchondral plate created using an awl to allow marrow element ingress. ACI comprised arthroscopic harvest of cartilage for chondrocyte expansion followed by mini-open implantation of the cell-seeded scaffold in the second stage. Single-stage BMAC involved iliac crest aspiration, bedside centrifugation to concentrate marrow elements and implantation beneath a collagen matrix via a mini-arthrotomy. Perioperative care included prophylactic antibiotics, regional or general anaesthesia and a standardised rehabilitation regimen tailored to the procedure: early controlled range of motion with protected weight bearing and progressive strengthening over weeks.

Follow up occurred at routine intervals with detailed clinical examination and patient-reported outcomes at six months and one year. Postoperative MRI with MOCART scoring and second-look arthroscopy were obtained when clinically indicated and feasible. Outcome measures included change in IKDC and KOOS (primary endpoints), MOCART MRI appearance and complication rates (secondary endpoints). Statistical analysis used paired comparisons for within-group changes and ANOVA for between-group comparisons with significance set at $p<0.05$. Data were analysed using standard statistical software.

Results

Of the 66 eligible patients, 53 (80.3%) completed the one-year follow up and were included in the final analysis. The cohort comprised 34 males and 19 females with a mean age of 32.7 years (SD 8.9) and mean BMI 24.44 kg/m^2. Mean defect area was 5.6 cm^2 (range 2.2–10.4 cm^2); 69.8% of lesions exceeded 4.0 cm^2. Procedures performed were arthroscopic microfracture in 33 patients (62.3%), single-stage BMAC in 15 (28.3%) and two-stage ACI in 5 (9.4%). Concurrent pathology requiring treatment (eg, meniscal tears, ACL injuries) was present in 54.7% and was addressed during the index procedure as appropriate.

At six months and one year, all three groups demonstrated statistically significant improvements in IKDC and KOOS relative to baseline ($p<0.05$ for within-group comparisons). Mean improvements were greater in younger patients and those with lower BMI. Between-group differences in mean IKDC and KOOS gains at one year did not reach statistical significance in this cohort, though subgroup sample sizes (particularly for ACI) were small. Postoperative MRI enabling MOCART scoring was available for 23 patients and generally indicated acceptable defect fill and integration across procedures. Complications were few and minor; there were no reported major procedure-related adverse events within the one-year follow up.

Discussion

This prospective single-centre series demonstrates that arthroscopic microfracture, single-stage BMAC and two-stage ACI each produced meaningful symptomatic and functional improvement at one year for symptomatic full-thickness femoral condyle defects. The clinical improvements observed align with prior epidemiological and cohort data indicating that appropriately selected patients derive benefit from both marrow-stimulation and restorative biologic techniques.3–8 Age, BMI and timing of surgery emerged as important correlates of outcome in this cohort, consistent with published series that identify younger patients and those treated earlier as more likely to experience substantial gains [8, 11, 15].

Microfracture remains a pragmatic, cost-effective option that delivers reliable short-term relief for many patients, particularly for smaller defects and lower-demand individuals, but it typically yields fibrocartilaginous repair tissue whose long-term biomechanical properties may be inferior to native hyaline cartilage [9–11]. Mosaicplasty and osteochondral grafting provide immediate hyaline cartilage restoration but are limited by donor site morbidity and size constraints [12–14]. ACI and matrix-assisted chondrocyte implantation have shown promising medium-term outcomes in multiple series but require two-stage procedures, cell expansion facilities and greater resources [13, 16].

Single-stage BMAC with a collagen matrix offers logistical advantages in a single operation and in this cohort produced early functional gains comparable to other techniques; however, variability in marrow concentrate preparation and lack of standardisation complicate cross-study comparisons and long-term efficacy remains to be established [15–18]. MRI assessment using standardized scoring such as MOCART provided useful non-invasive information about defect fill and integration in those patients imaged, but routine postoperative imaging and histological verification were not feasible for all participants in this series. Limitations of this study include non-randomised technique allocation influenced by surgeon preference and resource considerations, incomplete imaging for the entire cohort, small subgroup sizes (notably for ACI), and relatively short follow up of one year — all of which limit definitive between-technique comparisons and long-term inference [6, 19, 20].

Taken together with the broader literature, these findings support individualized treatment selection that balances lesion characteristics, patient factors, surgeon expertise and resource availability. Prospective randomized trials with standardized imaging protocols, second-look arthroscopy and histological assessment are required to determine technique-specific durability, cost-effectiveness and activity-related outcomes over the longer term [6, 17, 19].

Conclusion

In this prospective cohort of adults with symptomatic full-thickness femoral condyle defects ≥2.0 cm^2, arthroscopic microfracture, single-stage BMAC with collagen matrix and two-stage ACI each produced significant improvements in IKDC and KOOS scores at one year with low complication rates. Patient factors — especially younger age, lower BMI and shorter interval from injury to surgery — were associated with greater functional gains. Radiological assessment where obtained demonstrated acceptable defect fill and early repair integration. Within the limitations of non-randomised allocation, incomplete imaging and short follow up, no single technique proved clearly superior at one year. Individualised, evidence-informed decision-making and longer randomized studies with standardized imaging and histology are recommended to guide optimal management and resource allocation.

References

1. Kim J, Cho H, Young K, Park J, Lee J, Suh D. In vivo animal study and clinical outcomes of autologous atelocollagen-induced chondrogenesis for osteochondral lesion treatment. J Orthop Surg Res. 2015; 10. Doi: 10.1186/s13018-015-0212-x.
2. Chubinskaya S, Haudenschild D, Gasser S, Stannard J, Krettek C, Borrelli J. Articular Cartilage Injury and Potential Remedies. J Orthop Trauma. 2015; 29(Suppl):S47–S52.
3. Curl WW, Krome J, Gordon ES, Rushing J, Smith BP, Poehling GG. Cartilage injuries: a review of 31,516 knee arthroscopies. Arthroscopy. 1997 Aug; 13(4):456–60. Doi: 10.1016/S0749-8063(97)90124-9.

4. Widuchowski W, Widuchowski J, Trzaska T. Articular cartilage defects: Study of 25,124 knee arthroscopies. Knee. 2007; 14:177–82. doi:10.1016/j.knee.2007.02.001.
5. Flanigan DC, Harris JD, Trinh TQ, Siston RA, Brophy RH. Prevalence of chondral defects in athletes' knees: a systematic review. Med Sci Sports Exerc. 2010 Oct; 42(10):1795–801.
6. Migliorini F, Eschweiler J, Schenker H, Baroncini A, Tingart M, Maffulli N. Surgical management of focal chondral defects of the knee: a Bayesian network meta-analysis. J Orthop Surg Res. 2021; 16:543. Doi: 10.1186/s13018-021-02684-z.
7. Seo SS, Kim CW, Jung ADW. Management of Focal Chondral Lesion in the Knee Joint. Knee Surg Relat Res. 2011; 23(4):185–96.
8. Løken S, Heir S, Holme I, Engebretsen L, Årøen A. 6-year follow-up of 84 patients with cartilage defects in the knee. Acta Orthop. 2010 Oct; 81(5):611–8.
doi:10.3109/17453674.2010.519166.
9. Heir S, Nerhus TK, Røtterud JH, Løken S, Ekeland A, Engebretsen L, et al. Focal cartilage defects in the knee impair quality of life as much as severe osteoarthritis: knee injury and osteoarthritis outcome score in patients scheduled for knee surgery. Am J Sports Med. 2010 Feb; 38(2):231–7. Doi: 10.1177/0363546509352157.
10. Messner K, Maletius W. The long-term prognosis for severe damage to weight-bearing cartilage in the knee: a 14-year clinical and rad iographic follow-up in 28 young athletes. Acta Orthop Scand. 1996 Apr; 67(2):165–8.
Doi: 10.3109/17453679608994664.
11. Widuchowski W, Lukasik P, Kwiatkowski G, Faltus R, Szyluk K, Widuchowski J, et al. Isolated full thickness chondral injuries. Prevalence and outcome of treatment. A retrospective study of 5233 knee arthroscopies. Acta Chir Orthop Traumatol Cech. 2008 Oct; 75(5):382–6.
12. Willers C, Wood DJ, Zheng MH. A current review on the biology and treatment of articular cartilage defects (Part I & II). J Musculoskelet Res. 2003; 7:157–81.
Doi: 10.1142/S0218957703001125.
13. da Cunha Cavalcanti FMM, Doca D, Cohen M, Ferretti M. Updating on diagnosis and treatment of chondral lesion of the knee. Rev Bras Ortop. 2012 Jan; 47(1):12–20.
Doi: 10.1016/S2255-4971(15)30339-6.
14. Camp CL, Stuart MJ, Krych AJ. Current concepts of articular cartilage restoration techniques in the knee. Sports Health. 2014 May; 6(3):265–73.
Doi: 10.1177/1941738113508917.
15. Moyad TF. Cartilage Injuries in the Adult Knee: Evaluation and Management. Cartilage. 2011 Jul;2(3):226–36. Doi: 10.1177/1947603510383973.
16. Bedi A, Feeley BT, Williams RJ 3rd. Management of articular cartilage defects of the knee. J Bone Joint Surg Am. 2010 Apr; 92(4):994–1009. doi:10.2106/JBJS.I.00895.
17. Robinson PG, Williamson T, Murray IR, Al-Hourani K, White TO. Sporting participation following the operative management of chondral defects of the knee at mid-term follow up: a systematic review and meta-analysis. J Exp Orthop. 2020 Oct 6; 7(1):76. Doi: 10.1186/s40634-020-00295-x.
18. Chalmers PN, Vigneswaran H, Harris JD, Cole BJ. Activity-related outcomes of articular cartilage surgery: a systematic review. Cartilage. 2013 Jul; 4(3):193–203.
Doi: 10.1177/1947603513481603.
19. Litchfield RB, Kirkley A, Brimingham T, Giffin R, Willits K, Feagan B, et al. A randomized trial comparing arthroscopic surgery to non-surgical care for knee osteoarthritis. Arthroscopy. 2009.
20. Steadman JR, Rodkey WG, Briggs KK. Microfracture to treat full-thickness chondral defects: surgical technique, rehabilitation, and outcomes. J Knee Surg. 2002; 15(3):170–6.

Conflict of Interest: Nil
Source of Support: None

Institute where Research was Conducted: Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India
University Affiliation: Maharashtra University of Health Sciences (MUHS), Nashik, Maharashtra, India.
Year of Acceptance of Thesis: 2022

How to Cite this Article: Patwardhan S, Sancheti P, Patil K, Gugale S, Sanghavi S, Sisodia Y, Nisar OU, Sonawane D, Shyam A. Evaluation of Efficacy of Surgical Management for Treatment of Chondral Defects of the Knee in Adults. Journal of Medical Thesis . January-April 2024; 10(1):66-69.