Migliorini *et al.*
Journal of Orthopaedic Surgery and Research (2022) 17:524
https://doi.org/10.1186/s13018-022-03419-4

Journal of Orthopaedic Surgery and Research

REVIEW

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Surgical strategies for chondral defects of the patellofemoral joint: a systematic review

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Abstract

Background: The management of chondral defects of the patellofemoral joint is debated, and definitive evidence is lacking. This study systematically updated and summarised the current literature on the surgical management of isolated chondral defects of the patellofemoral joint, discussing techniques, outcome, pitfalls, and new frontiers.

Methods: This systematic review was conducted according to the 2020 PRISMA statement. In August 2022, PubMed, Web of Science, Google Scholar, and Embase databases were accessed with no time constrain. All the clinical studies investigating the surgical management of chondral defects of the patellofemoral joint were retrieved. Articles which reported data on patients with advanced to severe osteoarthritis were not eligible. Only studies with a minimum 24 months follow-up were considered. Studies which mixed results of patellofemoral and tibiofemoral joints were not considered.

Results: Data from 10 studies (692 procedures) were retrieved. The mean follow-up was 46.9 ± 18.2 months. The mean age of the patients was 34.0 ± 6.1 years, and the mean BMI was 25.9 ± 0.8 kg/m^2. The mean duration of symptoms before the index surgery was 81.0 ± 24.0 months. The mean defect size was 3.8 ± 0.8 cm^2. All the PROMs improved from baseline to last follow-up: VAS 0–10 ($P = 0.04$), Tegner ($P = 0.02$), Lysholm ($P = 0.03$), and International Knee Documentation Committee ($P = 0.03$). The rate of hypertrophy was 5.6% (14 of 251), the rate of progression to total knee arthroplasty was 2.4% (2 of 83), the rate of revision was 16.9% (29 of 136), and the rate of failure was 13.0% (16 of 123).

Conclusion: Current surgical strategies may be effective to improve symptoms deriving from chondral defects of the patellofemoral joint. The limited and heterogeneous data included for analysis impact negatively the results of the present study. Further clinical studies are strongly required to define surgical indications and outcomes, and the most suitable technique.

Keywords: Knee, Patellofemoral, Chondral defects, AMIC, mACI

Introduction

Chondral defects of the knee are common [1, 2]. Hyaline cartilage has limited regenerative capacities, and residual chondral defects are common [3, 4]. Non-symptomatic chondral defects are identified in up to 72% of patients undergo knee arthroscopy [5, 6]. Symptomatic chondral defects reduce considerably the quality of life and the participation to recreational activities of affected patients [7]. The management of patients with chondral defects is controversial, with unpredictable outcomes [8, 9]. Within the knee, chondral defects of the patellofemoral joint are common [10]. Chondral defects of the patellofemoral joint can lead to persistent anterior knee pain, and, if left untreated, to early osteoarthritis [7, 11, 12].

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Bone marrow stimulating surgical strategies, such as microfractures, are commonly performed for smaller defects [8, 9]. Autologous Matrix-Induced Chondrogenesis (AMIC) represent a further evolution of microfractures: a resorbable membrane is placed over the defect to stabilise the bone marrow-derived blood clot [13]. Autologous chondrocyte implantation (ACI), first generation (periosteal patch, pACI), second generation (chondral patch, cACI), and third generation (matrix-induced ACI, mACI), has been widely performed in the patellofemoral joint [14–16]. Current evidence on the surgical management of chondral defects of the patellofemoral joint is limited and mainly arises from studies which combined results with those of the femorotibial joint [17–20]. Few clinical trials which exclusively focused on the management of isolated chondral defects of the patellofemoral joint have been published [21–30]. This study systematically updated and summarised the current evidence on the surgical management of isolated chondral defects of the patellofemoral joint, discussing techniques, patient reported outcome measures (PROMs), pitfalls, and new frontiers.

Materials and methods

Eligibility criteria

All the clinical trials investigating the surgical management of chondral defects of the patellofemoral joint were accessed. Given the authors' language capabilities, articles in English, German, Italian, French, and Spanish were eligible. Only level I to IV of evidence, according to the Oxford Centre of Evidence-Based Medicine [31], were considered. Reviews, opinions, letters, and editorials were not considered. Only studies published in peer reviewed journals were considered. Animal, in vitro, biomechanics, computational, and cadaveric studies were not eligible. Articles which reported data on patients with advanced to severe osteoarthritis were not eligible. Studies which evaluated only the morphological quality of the newly formed cartilage were not eligible, nor were those reporting data from patients who previously underwent total knee arthroplasty (TKA). Only studies which reported the outcomes of patients undergoing surgical management for isolated chondral injuries of the patellofemoral joint (retropatellar, trochlear, or both) were considered. Only studies with a minimum 24 months follow-up were eligible. Studies which mixed results of patello- and tibiofemoral joints were not considered, nor were those which did not report quantitative data on the outcomes of interest.

Search strategy

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the 2020 PRISMA statement [32]. The PICOT framework was followed for the initial search:

- P (Problem): chondral defects of the patella;
- I (Intervention): surgical intervention;
- C (Comparison): baseline to follow-up improvement;
- O (Outcomes): PROMs and complications;
- T (Timing): minimum 24 months follow-up.

In August 2022 PubMed, Web of Science, Google Scholar, and Embase databases were accessed with no time constrain. The following keywords were used in combination using the Boolean operators AND/OR: *knee, patella, patellofemoral, kneecap, chondral, cartilage defect, ailment, injury, damage, chondropathy, management, treatment, graft, surgery, intervention, patient reported outcome measures, PROMs, IKCD, Lysholm, Tegner, VAS, visual analogue scale, pain, function, joint, outcome, failure, reoperation, and revision*.

Selection and data collection

The database search was conducted by two authors (F.M & A.B.) independently. All the resulting titles were carefully inspected and, if suitable, the abstract was accessed. The full-text of the abstracts which matched the topic was accessed. The bibliography of the full-text articles was also screened by hand to identify further articles. Disagreements were debated and the final decision was made by a third author (**).

Data items

Two authors (F.M & A.B.) independently conducted data extraction. Generalities of the included studies were retrieved: author and year, journal, study design, mean length of the follow-up, mean age of the patients, mean length of the symptoms prior the index procedure, and mean defect size. Data with regard to the following PROMs were collected at baseline and at last follow-up: Visual Analogue Scale (VAS), Tegner Activity Scale [33], Lysholm Knee Scoring Scale [34], and International Knee Documentation Committee (IKDC) [35]. Data on the following complications were also collected: rates of hypertrophy, failure, and revision surgery. The rate of progression to TKA was also retrieved. Patients with persistent symptoms of chondral damage were considered as failures.

Study risk of bias assessment

The study risk of bias assessment was performed by two authors (F.M & A.B.) independently. The risk of bias graft tool of the Review Manager software (The Nordic Cochrane Collaboration, Copenhagen) was used. The following biases were considered for analysis: selection, detection, reporting, attrition, and other source of bias.

Synthesis methods

The statistical analyses were conducted by the main author (F.M.) using the IBM SPSS Software. For continuous data, the mean difference (MD) and standard error (SE) were evaluated. The confidence intervals (CI) were set at 95% in all the comparisons. The t test was also performed, with values of $P<0.05$ considered statistically significant.

Results

Study selection

A total of 1644 articles were identified during the preliminary database search. Of them, 445 were excluded as they were duplicates. A further 1185 studies were excluded with reason: not focusing on patellofemoral joint ($N=901$), study type/design ($N=197$), and mixed patellofemoral and tibiofemoral data ($N=41$), including patients with osteoarthritis or only evaluated the quality of the new formed cartilage ($N=34$), language limitations ($N=9$), and short follow-up ($N=3$). Finally, further 4 studies were excluded as they did not report quantitative data under the outcomes of interest. The literature search resulted in 10 articles (Fig. 1).

Study risk of bias assessment

As a result of the lack of random sequence generation in most studies, the risk of bias tool evidenced a moderate risk of selection bias. Assessor blinding was seldom performed; thus, the risk of detection bias was moderate-high. However, the overall good quality of the investigations led to a moderate to low risk of attrition and reporting biases. The risk of other bias was moderate. Concluding, the risk of bias graph evidenced a moderate to low risk of publication bias (Fig. 2).

Study characteristics and results of individual studies

Data from 692 procedures were retrieved. The mean follow-up was 46.9 ± 18.2 months. The mean age of the patients was 34.0 ± 6.1 years, and the mean BMI was 25.9 ± 0.8 kg/m^2. The mean duration of the symptoms before the index surgery was 81.0 ± 24.0 months. The mean defect size was 3.8 ± 0.8 cm^2. Generalities of the studies are shown in Table 1.

Results of syntheses

All the PROMs improved from baseline to last follow-up (Table 2): VAS 0–10 (− 1.8; $P=0.04$), Tegner (+1.8; $P=0.02$), Lysholm (+13.5; $P=0.03$), and IKDC (+23.5; $P=0.03$).

The rate of hypertrophy was 5.6% (14 of 251), the rate of progression to TKA was 2.4% (2 of 83), the rate of revision was 16.9% (29 of 136), and the rate of failure was 13.0% (16 of 123).

Discussion

According to the main findings of the present study, current surgical strategies for chondral defects of the patellofemoral joint may be effective to improve symptoms. VAS, Tegner, Lysholm, and IKDC scores statistically significantly improved from baseline to last follow-up. The improvement of the PROMs overcome the minimum clinically important difference (MCID) [36–40]. However, the rate of complications was relatively high. The rate of hypertrophy was 5.6%, the rate of patients undergoing TKA was 2.4% (2 of 83), the rate of revision was 16.9% (29 of 136), and the rate of failure was 13.0% (16 of 123). Few authors reported the rate of complications: we assume that some authors did not report clearly whether complication were found. This may underestimate the number of patients who had experienced no complication.

Among the included studies, several techniques for cartilage regeneration have been used. PACI has been widely used to address chondral defects. Cultured autologous chondrocytes, harvested from healthy cartilage, are injected under a periosteal flap sutured over the defect [41]. PACI was burdened by a high rate of hypertrophy, which was attributed to the use of the periosteal flap [16, 42–46]. Indeed, in the present study, graft hypertrophy was almost seen only in patients who underwent pACI [26, 27]. To overcome this complication, collagen-membrane cover ACI (cACI) has been introduced, substituting the periosteal flap with a resorbable membrane [23, 47]. CACI evolved in mACI, in which the harvested and cultured autologous chondrocytes are seeded directly on a biodegradable scaffold, either a collagen type I/III matrix or hyaluronan matrix membrane [48]. The loaded matrix allows chondrocytes expansion and is secured with fibrin into the chondral defect in a second step surgery. Compared to the previous generation, mACI allows less invasive approaches (mini-arthrotomy or arthroscopy), avoids graft suture, and allows shorter surgical time [48]. Despite the good results in PROMs in long-term studies [49], these techniques are technically demanding, require two different surgical interventions, and are burdened by donor site morbidity, higher costs, and long recovery times [27, 48]. AMIC avoids cartilage harvest and external expansion, and is performed in a single surgical session. Different to ACI, which requires expanded autologous chondrocytes, AMIC exploits the potential of bone marrow-derived mesenchymal stem cells.

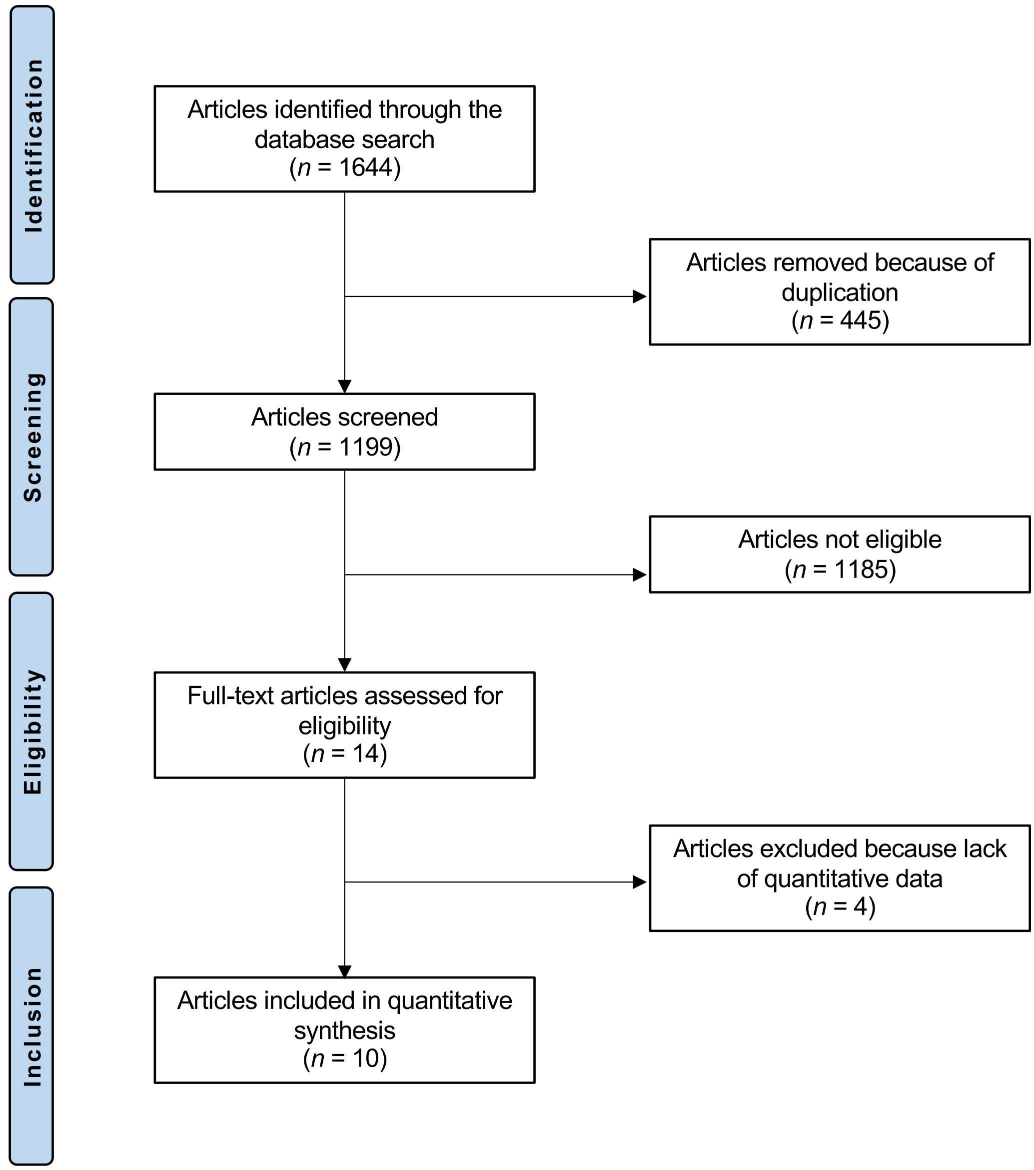

Fig. 1 Flow chart of the literature search

Most authors performed the procedures in patients with patellofemoral instability [21, 22, 26–30]. Up to 96% of patients following a patellar dislocation demonstrated cartilage damage at the patellofemoral joint [50–54]. Approximately 85% of patients following a patellar dislocation demonstrated focal patellar chondropathy at MRI, while 47% evidenced chondral damage in the trochlea [55–60]. The medial chondral facet and median crest of the patella were more commonly affected than the lateral patellar facet and femoral trochlea [51, 61–70]. Whether to combine a chondral procedure with a proximal or distal alignment to restore the appropriate patellar tracking is unclear. Patellofemoral instability is multifactorial, and its management is challenging [71]. The rate of re-dislocation after conservative management of first patellar dislocation ranges from 15 to 71% [72–83]. Surgery is reserved for patients who demonstrate loose bodies or large osteochondral defects [84–86]. There is a growing trend to manage surgically the first patellar dislocation [87, 88]. Previous investigations compared surgical versus conservative management for first patellofemoral dislocations, suggesting that patients may benefit from surgery immediately after the first acute patellar dislocation [89–98]. A recent meta-analysis found that the risk of

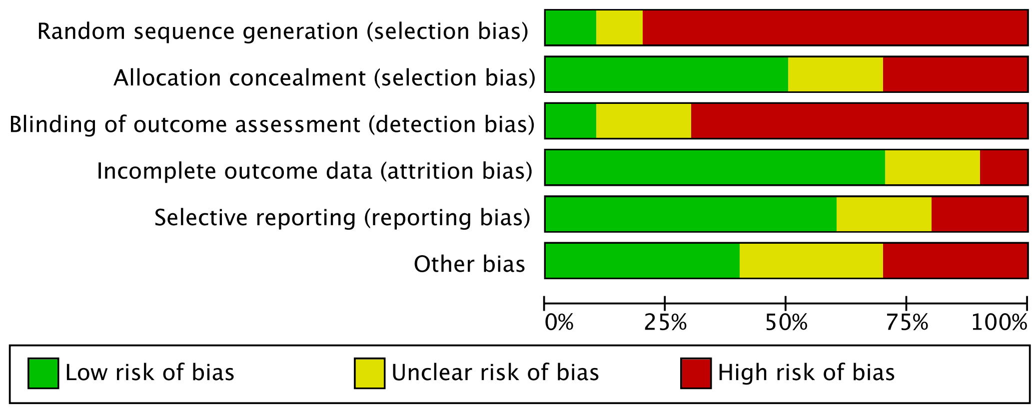

Fig. 2 Methodological quality assessment

Table 1 Generalities and patient baseline of the included studies

Author, year	Journal	Design	Follow-up (months)	Type of treatment	Patients (n)	Mean age
Buda et al. [21]	*Eur J Orthop Surg Traumatol*	Retrospective	48.0	ACI & BMC	28	38.0
Ebert et al. [22]	*Am J Sports Med*	Prospective	24.0	ACI III generation	10	39.0
				ACI III generation	13	36.0
				ACI III generation	9	38.0
				ACI III generation	15	37.0
Macmull et al. [23]	*Int Orthop*	Prospective	45.0	ACI II generation	25	35.0
			35.3	ACI III generation	23	35.0
Meyerkort et al. [24]	*Knee Surg Sports Traumatol Arthrosc*	Prospective	60.0	ACI III generation	23	42.0
Migliorini et al. [25]	*LIFE*	Prospective	43.7	AMIC	52	29.5
			39.5	Microfractures	31	31.3
Niemeyer et al. [26]	*Am J Sports Med*	Retrospective	38.0	ACI I generation	52	34.0
				ACI III generation	315	
Teo et al. [27]	*Clin Orthop Relat Res*	Retrospective	24.0	ACI I generation	20	16.8
				ACI & BMC	3	
Tradati et al. [28]	*J Clin Med*	Retrospective	68.2	AMIC	14	38.4
Von Keudell et al. [29]	*Cartilage*	Prospective	88.0	ACI I generation	30	32.0
Waltenspül et al. [30]	*Cartilage*	Prospective	49.2	AMIC	29	27.9

BMC bone marrow concentrate, *ACI* autologous chondrocyte implantation, *AMIC* autologous matrix-induced chondrogenesis

Table 2 Results of PROMs

Endpoint	Baseline	Last FU	MD	SE	95%CI	P
VAS	5.3 ± 1.3	3.5 ± 0.9	− 1.8	0.077	− 1.95 to − 1.64	0.04
Tegner	2.4 ± 0.2	4.2 ± 0.8	+ 1.8	0.045	1.71 to 1.88	0.02
Lysholm	55.0 ± 7.1	68.5 ± 5.9	+ 13.5	0.450	12.61 to 14.38	0.03
IKDC	50.1 ± 7.3	73.6 ± 12.2	+ 23.5	0.689	22.14 to 24.85	0.03

re-dislocation was 2.44 times greater in the conservative group, with a 10% worse Kujala score at approximately 5 years follow-up compared to a group of patients who underwent immediate surgery [99]. However, the management of the first patellar dislocation remains unclear [100], and international recommendations are lacking.

This systematic review presents several limitations which impact the reliability of the conclusions. In the current literature, several studies reported data on chondral procedures in the patellofemoral joint; however, most authors did not focus exclusively on the patellofemoral joint. Evidence focusing exclusively on the patellofemoral joint is limited and heterogeneous. Studies which focused on chondral procedures for patellar defects used different surgical procedures, including AMIC [25, 28, 30], pACI [26, 27, 29], cACI [23], mACI [22–24, 26], and ACI augmented with bone marrow concentrate [21, 27]. In this respect, results from the present investigation are not fully generalisable. Additional between studies heterogeneities should be discussed. Most authors performed the chondral procedures in patients with patellofemoral instability. Patients who experienced acute or recurrent patellar dislocations have different patterns of chondral injuries [54, 101, 102]. Several risk factors which predispose to patellofemoral instability have been described, such as patella alta, malalignment syndromes, ligamentous hyperlaxity, and dysplasia [103–106]. Recent studies demonstrated that most patients with patellofemoral instability have two or more coexistent pathoanatomical risk factors which synergistically predispose to the dislocation. Therefore, the results are strongly influenced by the underlying subjective pathoanatomical susceptibility to instability. Future investigations should clarify the outcome of combined patellofemoral and chondral procedures, to establish the proper surgical management. Furthermore, some authors performed the chondral procedures in isolation [22, 25], while some others combined the procedure with proximal or distal alignments to restore physiological patellar tracking [21, 22, 26–29]. Eight studies focused on isolated retropatellar chondral injuries [22, 23, 25–30], one only on isolated trochlear injuries [22], and two reported data from mixed locations [21, 24]. Two studies enhanced ACI with autologous bone marrow aspirate concentrate [21, 27]. Moreover, most studies used a collagenic I/III porcine derived membrane, while Buda et al. 2018 [21] used a hyaluronic membrane. Most authors considered only patients with no previous chondral intervention on the knee [25, 29]; other authors considered also revision settings [22, 23, 26]. Finally, most authors included only patients with single unipolar patellofemoral joint focal defects [21, 22, 25, 28, 29], while others included also patients with mixed locations [23]. The impact of these variables on the surgical outcomes is unknown. However, given the lack of quantitative data available in the literature, further subgroup analyses were not possible. Given these limitations in original studies, additional subgroups analyses were not possible, and results from the present study must be interpreted with caution. Further clinical studies to define eligibility criteria, surgical indications and techniques are strongly required.

Conclusions

Surgical strategies may be effective to improve symptoms of chondral defects of the patellofemoral joint. The rate of complications was relatively high. The limited and heterogeneous data included for analysis impact negatively the generalisability of the results of the present study. Further clinical studies are strongly required to define surgical indications and outcomes, and the most suitable technique.

Abbreviations

MCID: Minimum clinically important difference; BMC: Bone marrow concentrate; ACI: Autologous chondrocyte implantation; AMIC: Autologous matrix-induced chondrogenesis; VAS: Visual analogue scale; IKDC: International Knee Documentation Committee; MD: Mean difference; SE: Standard error; CI: Confidence intervals; AMIC: Autologous Matrix-Induced Chondrogenesis; ACI: Autologous chondrocyte implantation; pACI: Periosteal patch autologous chondrocyte implantation; cACI: Chondral patch autologous chondrocyte implantation; mACI: Matrix-induced autologous chondrocyte implantation; PROMs: Patient reported outcome measures; TKA: Total knee arthroplasty.

Acknowledgements

None.

Author contributions

FM contributed to literature search, data extraction, methodological quality assessment, statistical analyses, and writing; NM contributed to supervision and revision; AB contributed to literature search, data extraction, methodological quality assessment, and writing; GV, CW, and FH contributed to revision and supervision. All authors have agreed to the final version to be published and agree to be accountable for all aspects of the work.

Funding

Open Access funding enabled and organized by Projekt DEAL. This research received no external funding.

Availability of data and materials

The datasets generated during and/or analysed during the current study are available throughout the manuscript.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

Professor Maffulli is the Editor in Chief of the Journal of Orthopaedic Surgery and Research.

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Received: 28 October 2022 Accepted: 24 November 2022
Published online: 05 December 2022

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