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Clinical outcome after mosaicplasty of knee articular cartilage defects of patellofemoral joint versus tibiofemoral joint

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ABSTRACT

Background: The purpose was to investigate survival of cartilage repair in the knee joint by osteochondral autograft transfer stratified by location of the lesion; patellofemoral joint (N = 26) versus the medial or lateral femoral condyles (N = 58).
Methods: For survival analyses, "failure" was defined as the event of a patient reporting a poor Lysholm score (below 65 points) or undergoing a knee replacement procedure.
Results: The survival distribution was not significantly different between the patellofemoral joint and the tibiofemoral joint groups.
Conclusions: The current study suggest that similar long-term outcome can be expected after OAT procedures for the patellofemoral or tibiofemoral joint.
Level of evidence: Therapeutic study, Level III.

1. Introduction

Focal chondral lesions of the knee impair quality of life to a similar degree as in patients scheduled for knee replacement[1] and provoke symptoms and reduced function to a greater degree than that of patients about to undergo a reconstruction of a torn anterior cruciate ligament.[2] Hjelle and co-workers found focal chondral lesions in 19% of 1000 consecutive knee arthroscopies.[3] They were localized to the medial femoral condyle in 58%, patella in 11%, lateral tibia in 11%, lateral femoral condyle in 9%, trochlea in 6%, and the medial tibia in 5%. Thus, patellofemoral joint (PF) lesions constituted 17% and medial- or femoral condyle (FC) 67% of the chondral defects of the knee.[3]

Chondral lesions do not heal spontaneously and continue to pose a therapeutic challenge to orthopaedic surgeons.[4,5] Thus, since the early 1990s a number of new surgical treatment options have been introduced including osteochondral autograft transfer (OAT) from less weight-bearing areas of the knee joint to the defect.[6–8] The technique was popularized by Hangody et al. under the name *mosaicplasty*[9,10] as grafts are placed in a mosaic fashion to cover most of the defect.

Some studies have suggested that localization of the cartilage lesion might affect outcome after surgery, specifically, that inferior results are seen in PF lesions. However, a firm conclusion is yet to be established as results are contractionary, possibly due to great differences in study design.[11–18]

We have previously published short-, medium- and long-term outcome of articular cartilage repair of the knee using the mosaicplasty technique.[19–24] The present work aimed, for the first time, to compare the long-term survival (by the Kaplan-Meier method) of the cartilage repair by OAT of PF lesions versus FC lesions. The null-hypothesis was that the occurrence of failure was not different between the two groups of different sites.

2. Materials and methods

2.1. Experimental protocol

All patients undergoing a cartilage repair procedure at our institution from 1998 to 2003 were registered prospectively in a local institutional database (Access, Microsoft Corporation, Redmond, USA). The baseline data were acquired from standardized forms completed by both the patient and the surgeon. The form contained details about preoperative symptoms and function (including that of the Lysholm knee score)[25] and perioperative findings and details about the surgery performed, including localization and size of the articular cartilage defect, similar to the system recommended by the International Cartilage Repair Society.[26]

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We included patients of age 60 years or younger at surgery; with a symptomatic focal full-thickness articular chondral defect of the patellofemoral joint (patella or trochlea, PF group) or the medial or lateral femoral condyles (FC group) verified by arthroscopic examination and treated with mosaicplasty. Exclusion criteria (at the time of surgery) were: joint space narrowing on standard anteroposterior radiographs (to a space < 4 mm), more than 5° varus or valgus malalignment, previous or concurrent realignment surgery, ligament instabilities or the inability to follow the rehabilitation protocol.

Outcome evaluation was performed by the Lysholm score[25,27] and any report of the patient undergoing a knee replacement surgery of the same knee (after the index surgery). Data were prospectively collected at several time-points after the surgery. For the first few years, data were collected at routine check-ups at the out-patient department, thereafter by the patients completing and returning standardized questionnaires sent (by researchers not involved in the treatment) by mail every 2–3 years, most recently in 2017.

2.2. Surgical techniques

After arthroscopic evaluation, a mosaicplasty procedure was performed. The lesion was debrided with curettes down to subchondral bone, and around the edges until healthy surrounding cartilage. The area of the lesion was calculated (after the debridement) as millimetres squared. The mosaicplasty procedure (Smith and Nephew Inc., Andover, MA, USA) was performed as described by Hangody et al.[9,10] The grafts were harvested from the periphery of the femoral condyles at the level of the patellofemoral joint and transplanted to corresponding burr holes in the defect in a mosaic fashion in the effort to cover as much as possible of the area of the lesion. Most lesions on the medial femoral condyle was treated by a medial parapatellar mini-arthrotomy, used both for harvesting (in knee extension) and transplantation (in knee flexion) of the grafts. In all patellofemoral joint lesions, a standard arthrotomy with eversion of the patella was undertaken.

2.3. Rehabilitation

For all patients, continuous passive motion was started within a few hours after the operation and was continued for the duration of the stay in hospital (4–7 days). The patients were instructed in use of crutches by a physiotherapist and maintained foot-touch weight-bearing for 6 weeks. Thereafter, full weight-bearing was gradually introduced. Physiotherapy was commenced at the hospital and continued after the discharge. Initial exercises included stretching, straight-leg raise and passive motion - progressing through active closed kinetic chain exercises including stationary bicycling to dynamic weight training.[28] The Ethical Committee at our institution reviewed and approved of the study (HDS ID 1998–0201). All patients gave their informed consent prior to inclusion in the study.

2.4. Statistical analyses

Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, USA) on a personal computer. An a priori *P*-value less than 0.05 was considered statistically significant. As measures of central location and spread of data, mean and standard deviation (SD) or median and range were calculated. A two-tailed unpaired T-test was used to compare the sets of continuous data between subgroups of the patient population (at the same time point). For comparing binominal data of subgroups, the chi-square test was used.

For survival analyses, "failure" was defined as the patient reporting a poor Lysholm score below 65 points (from 12 months after the surgery and onwards - when patients had normally finished their rehabilitation)[25] and/or undergoing an ipsilateral knee replacement procedure.[23] Time from the index cartilage surgery until the event of failure was recorded and used for analyses. The Kaplan-Meier method was used for construction of a survival functions plot for the event "failure". Log Rank (Mantel-Cox) test was used for comparison of survival distributions in the two groups (PF and FC).[29]

Table 1
Demographic data for patients (N = 84) undergoing mosaicplasty of the patellofemoral joint (PF) or the femoral condyles (FC). Mean (SD).

	PF (N = 26)	FC (N = 58)	P-value
Male/Female	12/14	37/21	0.13 (n.s.)
Age at surgery	35 (10)	35 (9)	0.91 (n.s.)
Duration of symptoms (months)	68 (57)	82 (80)	0.44 (n.s.)
Right/Left knee	21/5	36/22	0.09 (n.s.)
Treated area (mm^2)	290 (124)	298 (123)	0.76 (n.s.)
Baseline Lysholm score (Lys)	41 (17)	49 (14)	0.02[a]

[a] Statistically significant difference.

3. Results

84 patients (35 women and 49 men) with median age 34 years (Range 16–60) were included in the study. Twenty-six (PF group) patients were treated by mosaicplasty for an articular cartilage defect of the patella (N = 19) or trochlea (N = 7). Fifty-eight (FC group) were treated for a lesion on the medial (N = 51) or lateral (N = 7) femoral condyle.

At the time of surgery, the median symptom duration was 48 months (Range 1–360). The median total area of cartilage defect(s) treated was 300 (Range 100–500) mm^2, with the use of median 4 osteochondral grafts (Range 1–11). The right knee N = 57 (68%) was more often treated than the left knee N = 27 (32%). The two groups did not differ significantly regarding distribution of gender; mean age at surgery; mean duration of symptoms at the time of surgery; distribution of right versus left knee; or the mean treated area (Table 1). The PF group reported significantly lower baseline Lysholm score (Table 1).

The frequency of knee replacement surgery (KR) and poor outcome/failure (Lysholm < 65 or KR), and mean time to failure were not significantly different between the groups (Table 2). The survival distribution (Fig. 1) was not significantly different between the patellofemoral joint and the tibiofemoral joint groups, Log Rank (Mantel-Cox) 0.117 ($P = 0.732$).

4. Discussion

The most important finding of the present study was that the survival distribution was not significantly different between the patellofemoral joint and the tibiofemoral joint groups (N.s). The results therefore suggest that similar long-term clinical effectiveness can be expected after undergoing mosaicplasty of knee articular cartilage lesions in the patellofemoral joint and the tibiofemoral joint. For both sites, most of the OAT repairs remained intact (per definition of the study) for many years, but eventually gradually failed within the 18-year follow-up in about 50%, in both groups. Still, we concur that many patients have had a reasonably good knee function for many years after the OAT procedure. Further, one may speculate that the development of symptomatic osteoarthritis has possibly been postponed by the cartilage repair in (both localizations). To our best knowledge, this is the first

Table 2
Frequency of knee replacement surgery (KR) in same knee, frequency of failure (Lys < 65 or KR), and mean time (years) to failure. Mean (SD).

	PF (N = 26)	FC (N = 58)	P-value
Knee replacement (KR). N (%)	N = 5 (19%)	9 (16%)	0.8 (n.s.)
Poor (Lys < 65 or KR). N (%)	15 (58)	28 (48)	0.5 (n.s.)
Time to failure.	9 (5)	8 (5)	0.3 (n.s.)

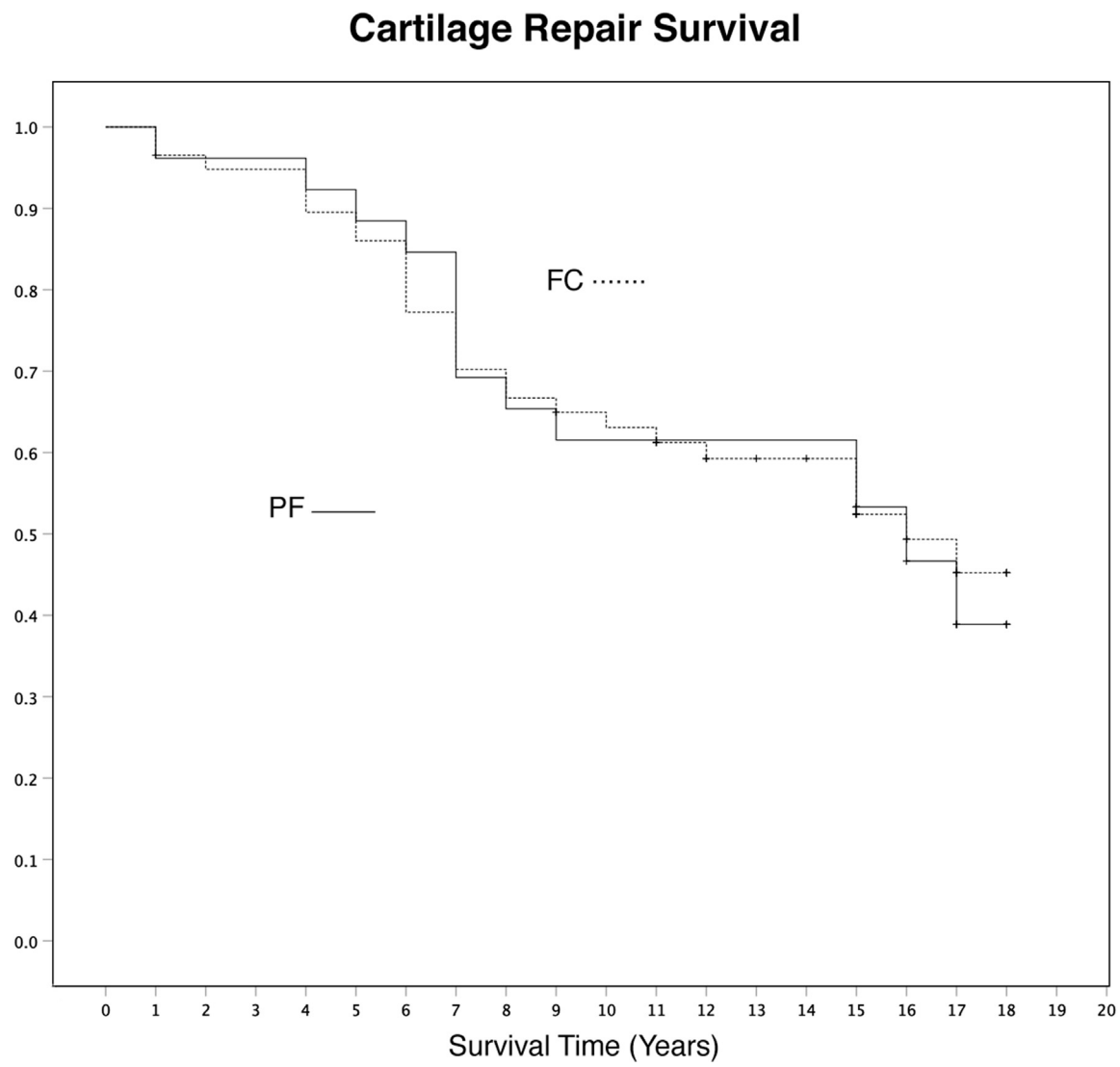

Fig. 1. Kaplan-Meier survival functions plot for the event "failure" (a knee replacement procedure in the same knee or Lysholm score < 65) after cartilage repair surgery (PF solid line; FC dashed line; + censored data).

study to compare the long-term survival of the cartilage repair by OAT of PF lesions versus FC lesions.

The PF group reported a significantly lower baseline Lysholm than that of the FC group. Low baseline Lysholm score has been identified as an important predictor for worse outcome in cartilage repair surgery.[30] Further, the majority of the FC defects was managed by a short medial parapatellar incision, whereas a large arthrotomy with luxation of the patella was warranted for all the PF cases. Both factors (lower baseline Lysholm and more invasive surgery) would probably represent a worse prognosis in the PF group. Still, we found no significant difference in the long-term outcome, enhancing the impression that a PF localization is in no way a contraindication for performing an OAT procedure.

In the present study, the Lysholm score was used for knee rating regarding symptoms and function. This decision was made when the quality database was established more than 20 years ago. Newer, more modern knee rating scores may have been preferred today. Still, recently reported studies of cartilage surgery using Lysholm score is prevailing[12,18,20–24,28,31] and the score has indeed proven adequate psychometric performance for outcome assessment of various chondral disorders of the knee.[27] Failure was defined as a poor clinical outcome (Lysholm score < 65 points)[25] or a knee replacement procedure,[31] whichever event that took place first.[23] Other authors have included other more minor re-interventions (than a knee replacement) as a failure.[32] However, by including the event of Lysholm score dropping below 65 points as a failure, any relevant re-intervention would generally be picked up, as it would be predated (and initiated) by a poor outcome (even if the new procedure improved the symptoms and precluded/delayed a knee replacement).

One of the main difficulties in measuring the outcome of long-term clinical studies on articular cartilage repair is that an increasing percentage of the patients are having a knee replacement. As a knee score is often the main outcome variable, authors tend to exclude the replacement cases, acknowledging that the score represents the knee replacement and not the original cartilage report. However, by reporting the average score for only the non-failures, a large bias (towards reporting a much too optimistic results) is introduced.[31] Further, "failure" is generally restricted to the occurrence of a knee replacement, disregarding the fact that many patients experience a poor result, without undergoing a knee replacement. Thus, we have suggested defining failure as a poor Lysholm score < 65 in addition to undergoing a knee replacement procedure.[21,23]

Another important difficulty in long-term clinical studies on articular cartilage repair is maintaining an acceptable follow-up rate as the patients move; get bored answering the questionnaires; get old and mentally reduced; or die. Using survival analyses solves this issue by introducing "censored data", the recording of the latest point of time of

survival, in patients with a repair that do not fail during the study period.[23,29,31,32]

We observed a gradual accumulation of failures of the OAT cartilage repair in both groups (of different localization). In contrast to cell-based techniques such as microfracture (mesenchymal stem cells) and ACI (chondrocytes), the OAT procedures does not rely on cell multiplication and differentiation, which may, unfortunately, result in other types of connective tissue than articular hyaline cartilage.[28] Thus, at the end of the OAT procedure, the former articular cartilage defect has already been replaced by a mosaic of transplants of normal hyaline cartilage and subchondral bone.[9] Experimental animal studies and human clinical studies have shown that osteochondral grafts maintain their hyaline cartilage coverage and that the subchondral bony part unites with the surrounding bone.[9,33] However, the long-term results may be hampered by the donor site morbidity; inadequate bonding between the cartilage cylinder grafts and towards the normal surrounding cartilage; and any non-geometric/anatomic reconstruction, including proud or short/low cylinders and incorrect angle placements.[34–37] These factors, in addition to any other inherit predisposing factor (genetic, physiological or mechanical) may explain the tendency to development of osteoarthritis (OA) in the long run and deterioration of the clinical outcome over time.[20,22,23]

Regarding the influence of the localization of the articular cartilage defect on the outcome, conclusions from previous reports are somewhat contradictory. Still, it seems that most studies on this subject conclude with a poorer outcome after OAT procedure in PF joint lesions compared to that of the FC. However, some of the studies are hampered with various short-comings (including study design, short follow-up and small number of included patients), and the scientific evidence, in our respectful opinion, for the latter conclusion, is weak. Bentley et al.[11] compared OAT (N = 42) and ACI (N = 58) procedure with a mean follow-up of 19 (Range, 12–26) months. Regarding the OAT group, the macroscopic ICRS grading of the repair tissue at one year (by routine arthroscopy) was significantly inferior in the patella cases (N = 5) compared to lesions located on the femur.[11] Hangody et al.[12] reported on the outcome of mosaicplasty procedures (N = 831), mostly in the knee, including 597 FC and 118 PF procedures performed at their institutions between February 1992 and February 2002. Based on various knee scores (including the Lysholm score), they found a significantly higher good-to-excellent outcome rate in the FC group (91%) compared to the PF group (74%) at 1–10 year of follow-up.[12]

Ollat et al.[14] performed a minimum 5-year retrospect multicentre follow-up study of 142 patients with cartilage lesions of various locations. They found that medial condyle defects had significantly better ICRS clinical and Hughston scores than lateral condyle or PF joint defects (N = 11).[14] Panics et al.[15] followed 61 soccer players who underwent mosaicplasty and performed the final evaluation at an average of 10 (range, 2–17) years. There were five PF cartilage lesions in their series (4 patella, 1 trochlea). None of these patients were able to return to their professional sport after the treatment, whilst 79% of those who were treated for a FC lesion did.[15] Baltzer et al.[16] performed a short-to mid-term (mean 26 months) follow-up study of 112 middle-aged (mean 48 years) patients who had had an OAT procedure of cartilage lesions of varying location, identifying possible predictors of clinical outcome, evaluated by WOMAC Index and the Visual Analogue Scale (VAS) for pain. They found lesion location at the patella to be the only significant risk factor for a poor result.[16]

In contrast, some recent studies report satisfactory outcome after OAT procedure on the patella[17] and the PF joint.[13,18] Karataglis et al. followed 36 patients (37 procedures) for mean 37 (Range, 18–73) months after an OAT procedure that was located to the FC in 26 cases and PF joint in 11 cases.[13] They concluded that no correlation was found between patient age, the size of the lesion or its localization and the functional outcome as depicted by the Tegner activity scale and the Activities of Daily Living Scale of the Knee Outcome Survey.[13]

Further, Emre et al. reviewed retrospectively 33 patients who underwent mosaicplasty for PF cartilage defects.[18] All patients were followed for 12–24 months (mean 19 months) using Lysholm knee score for evaluation of the clinical outcome. The mean Lysholm knee score increased from 52 points at baseline to 86 at the final follow-up ($P < 0.001$). The results were good in 24 cases and fair in 9 cases. No patients had poor results. Chadli et al. reported on the clinical outcome at a 16–50 months follow-up (Mean 29 months) on a series of 8 cases of OCD of the patella in (12-17 year-old) adolescents treated by mosaicplasty.[17] From baseline to the last follow-up a significant improvement was observed in the mean Lysholm score from 54 to 89, and mean IKDC score from 50 to 87. Radiographs and MRI showed a complete integration of grafts at the latest follow-up with a satisfactory reconstruction of the joint surface.

The strengths of the current study include a rather large population (N = 84); a robust outcome measure, failure, defined as a knee replacement or a poor Lysholm score; a high follow-up rate, 100%, by including both failures and censored data; a long total follow-up time approaching 20 years; the use of prospective registration of data; and the inclusion of a patient administered outcome score. The weaknesses include the lack of a routine second-look arthroscopy; an MRI examination to evaluate the repair; or a routine radiological evaluation of the development of osteoarthritis. Also, no non-operatively treated control-group was included for evaluation of the effectiveness of surgery versus the natural course of knee joint cartilage lesions.

5. Conclusion

The most important finding of the present study was that the survival distribution was not significantly different between the patellofemoral joint and the tibiofemoral joint groups. For both sites, most of the OAT repairs stayed intact for many years, but eventually failed within 18 years in almost half of the cases. Still, we concur that many patients have had a reasonably good knee function for many years after the OAT procedure, independent on the localization (PF or FC).

Declaration of competing interest

On behalf of the authors of the manuscript titled: “Clinical outcome after mosaicplasty of knee articular cartilage defects of patellofemoral joint versus tibiofemoral joint” submitted for possible publication in Journal of Orthopaedics, I hereby declare that none of the authors/coauthors, their families or any research foundation with which they are affiliated did receive any financial payment or other benefits from any commercial entity related to the subject of this article.

References

1. Heir S, Nerhus TK, Røtterud JH, et al. Focal cartilage defects in the knee impair quality of life as much as severe osteoarthritis: a comparison of knee injury and osteoarthritis outcome score in 4 patient categories scheduled for knee surgery. *Am J Sports Med.* 2010;38:231–237. https://doi.org/10.1177/0363546509352157.
2. Solheim E, Krokeide AM, Melteig P, Larsen A, Strand T, Brittberg M. Symptoms and function in patients with articular cartilage lesions in 1,000 knee arthroscopies. *Knee Surg Sport Traumatol Arthrosc.* 2016;24:1610–1616. https://doi.org/10.1007/s00167-014-3472-9.
3. Hjelle K, Solheim E, Strand T, Muri R, Brittberg M. Articular cartilage defects in 1,000 knee arthroscopies. *Arthroscopy.* 2002;18:730–734.
4. Hunziker EB, Lippuner K, Keel MJB, Shintani N. An educational review of cartilage repair: precepts & practice–myths & misconceptions–progress & prospects. *Osteoarthr Cartil.* 2015;23:334–350. https://doi.org/10.1016/j.joca.2014.12.011.
5. Niemeyer P, Feucht MJ, Fritz J, Albrecht D, Spahn G, Angele P. Cartilage repair surgery for full-thickness defects of the knee in Germany: indications and epidemiological data from the German Cartilage Registry (KnorpelRegister DGOU). *Arch Orthop Trauma Surg.* 2016;136:891–897. https://doi.org/10.1007/s00402-016-2453-5.
6. Matsusue Y, Yamamuro T, Hama H. Arthroscopic multiple osteochondral transplantation to the chondral defect in the knee associated with anterior cruciate ligament disruption. *Arthroscopy.* 1993;9:318–321.
7. Hangody L, Kárpáti Z. [New possibilities in the management of severe circumscribed cartilage damage in the knee]. *Magy Traumatol Ortop Kezseb Plasztikai Seb.* 1994;37:237–243.

8. Bobic V. Arthroscopic osteochondral autograft transplantation in anterior cruciate ligament reconstruction: a preliminary clinical study. *Knee Surg Sport Traumatol Arthrosc.* 1996;3:262–264.
9. Hangody L, Kish G, Kárpáti Z, Szerb I, Udvarhelyi I. Arthroscopic autogenous osteochondral mosaicplasty for the treatment of femoral condylar articular defects. A preliminary report. *Knee Surg Sport Traumatol Arthrosc.* 1997;5:262–267.
10. Hangody L, Ráthonyi GK, Duska Z, Vásárhelyi G, Füles P, Módis L. Autologous osteochondral mosaicplasty. Surgical technique. *J Bone Joint Surg Am.* 2004;86-A:65–72 Suppl 1.
11. Bentley G, Biant LC, Carrington RWJ, et al. A prospective, randomised comparison of autologous chondrocyte implantation versus mosaicplasty for osteochondral defects in the knee. *J Bone Joint Surg Br.* 2003;85:223–230.
12. Hangody L, Füles P. Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. *J Bone Joint Surg Am.* 2003;85-A:25–32 Suppl 2.
13. Karataglis D, Green MA, Learmonth DJA. Autologous osteochondral transplantation for the treatment of chondral defects of the knee. *The Knee.* 2006;13:32–35. https://doi.org/10.1016/j.knee.2005.05.006.
14. Ollat D, Lebel B, Thaunat M, et al. Mosaic osteochondral transplantations in the knee joint, midterm results of the SFA multicenter study. *Orthop Traumatol Surg Res.* 2011;97:S160–S166. https://doi.org/10.1016/j.otsr.2011.08.005.
15. Pánics G, Hangody LR, Baló E, Vásárhelyi G, Gál T, Hangody L. Osteochondral autograft and mosaicplasty in the football (soccer) athlete. *Cartilage.* 2012;3:25S. https://doi.org/10.1177/1947603511408286.
16. Baltzer AWA, Ostapczuk MS, Terheiden HP, Merk HR. Good short- to medium-term results after osteochondral autograft transplantation (OAT) in middle-aged patients with focal, non-traumatic osteochondral lesions of the knee. *Orthop Traumatol Surg Res.* 2016;102:879–884. https://doi.org/10.1016/j.otsr.2016.06.004.
17. Chadli L, Cottalorda J, Delpont M, Mazeau P, Thouvenin Y, Louahem D. Autologous osteochondral mosaicplasty in osteochondritis dissecans of the patella in adolescents. *Int Orthop.* 2017;41:197–202. https://doi.org/10.1007/s00264-016-3198-z.
18. Emre TY, Atbasi Z, Demircioglu DT, Uzun M, Kose O. Autologous osteochondral transplantation (mosaicplasty) in articular cartilage defects of the patellofemoral joint: retrospective analysis of 33 cases. *Musculoskelet Surg.* 2017;101:133–138. https://doi.org/10.1007/s12306-016-0448-6.
19. Solheim E. [Mosaicplasty in articular cartilage injuries of the knee]. *Tidsskr Nor Laegeforen.* 1999;119:4022–4025.
20. Solheim E, Hegna J, Øyen J, Austgulen OK, Harlem T, Strand T. Osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee: results at 5 to 9 years. *The Knee.* 2010;17:84–87. https://doi.org/10.1016/j.knee.2009.07.007.
21. Solheim E, Hegna J, Øyen J, Harlem T, Strand T. Results at 10 to 14 years after osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee. *The Knee.* 2013;20:287–290. https://doi.org/10.1016/j.knee.2013.01.001.
22. Solheim E, Hegna J, Inderhaug E. Long-term clinical follow-up of microfracture versus mosaicplasty in articular cartilage defects of medial femoral condyle. *The Knee.* 2017;24:1402–1407. https://doi.org/10.1016/j.knee.2017.08.061.
23. Solheim E, Hegna J, Inderhaug E. Long-term survival after microfracture and mosaicplasty for knee articular cartilage repair: a comparative study between two treatments cohorts. *Cartilage.* 2018;18. https://doi.org/10.1177/1947603518783482 1947603518783482.
24. Solheim E, Hegna J, Strand T, Harlem T, Inderhaug E. Randomized study of long-term (15-17 Years) outcome after microfracture versus mosaicplasty in knee articular cartilage defects. *Am J Sports Med.* 2018;46:826–831. https://doi.org/10.1177/0363546517745281.
25. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res.* 1985;198 43–9.
26. Brittberg M, Winalski CS. Evaluation of cartilage injuries and repair. *J Bone Joint Surg Am.* 2003;85-A:58–69 Suppl 2.
27. Kocher MS, Steadman JR, Briggs KK, Sterett WI, Hawkins RJ. Reliability, validity, and responsiveness of the Lysholm knee scale for various chondral disorders of the knee. *J Bone Joint Surg Am.* 2004;86-A 1139–45.
28. Knutsen G, Engebretsen L, Ludvigsen TC, et al. Autologous chondrocyte implantation compared with microfracture in the knee. A randomized trial. *J Bone Joint Surg Am.* 2004;86-A:455–464.
29. Singh R, Mukhopadhyay K. Survival analysis in clinical trials: basics and must know areas. *Perspect Clin Res.* 2011;2:145–148. https://doi.org/10.4103/2229-3485.86872.
30. Solheim E, Hegna J, Inderhaug E. Early determinants of long-term clinical outcome after cartilage repair surgery in the knee. *J Orthop.* 2018;15:222–225. https://doi.org/10.1016/j.jor.2018.01.021.
31. Knutsen G, Drogset JO, Engebretsen L, et al. A randomized multicenter trial comparing autologous chondrocyte implantation with microfracture: long-term follow-up at 14 to 15 years. *J Bone Jt. Surg.* 2016;98:1332–1339. https://doi.org/10.2106/JBJS.15.01208.
32. Gudas R, Gudaite A, Pocius A, et al. Ten-year follow-up of a prospective, randomized clinical study of mosaic osteochondral autologous transplantation versus microfracture for the treatment of osteochondral defects in the knee joint of athletes. *Am J Sports Med.* 2012;40:2499–2508. https://doi.org/10.1177/0363546512458763.
33. Hangody L, Kish G, Kárpáti Z, Udvarhelyi I, Szigeti I, Bély M. Mosaicplasty for the treatment of articular cartilage defects: application in clinical practice. *Orthopedics.* 1998;21:751–756.
34. Simonian PT, Sussmann PS, Wickiewicz TL, Paletta GA, Warren RF. Contact pressures at osteochondral donor sites in the knee. *Am J Sports Med.* 1998;26:491–494. https://doi.org/10.1177/03635465980260040201.
35. Jakob RP, Franz T, Gautier E, Mainil-Varlet P. Autologous osteochondral grafting in the knee: indication, results, and reflections. *Clin Orthop Relat Res.* 2002:170–184.
36. Andrade R, Vasta S, Pereira R, et al. Knee donor-site morbidity after mosaicplasty - a systematic review. *J Exp Orthop.* 2016;3:31. https://doi.org/10.1186/s40634-016-0066-0.
37. Nakagawa Y, Mukai S, Yabumoto H, Tarumi E, Nakamura T. Serial changes of the cartilage in recipient sites and their mirror sites on second-look imaging after mosaicplasty. *Am J Sports Med.* 2016;44:1243–1248. https://doi.org/10.1177/0363546516634299.