Outcomes and clinical role of osteochondral allograft transplantation

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Full-thickness articular cartilage defects of the knee are a significant cause of patient morbidity. As treatment options have expanded, existing treatment algorithms have become increasingly complex (1,2). Osteochondral allograft and autograft transplantation (in this article, OAT refers exclusively to osteochondral allograft transplantation) have received increasing attention for the treatment of full-thickness cartilage defects since their initial study (3-5). Osteochondral allograft transplantations (OATs) are typically reserved for lesions greater than 2 cm^2, and commonly with subchondral plate or bone involvement. As surgical techniques and indications have improved, OAT studies have increasingly focused on patient outcomes (6,7).

In the current study, Frank *et al.* report on outcomes and failures of 180 patients receiving OAT at a high-volume cartilage restoration center with a mean 5-year follow-up. The failure rate is an encouragingly low 13% at a mean time to failure of 3.6 years (SD 2.6). This mean time to failure highlights the importance of adequate length of follow-up for studies reporting on failure rates for this technique. Failure in this study was defined as revision OAT, conversion to arthroplasty, or graft failure at second-look arthroscopy by gross visual appearance. In general, according to a 2013 systematic review of 19 studies evaluating clinical outcomes of OAT, overall failure rates are reported to be 18% (8). However, no specific set of criteria to define OAT failures exist and this makes direct comparisons among retrospective outcomes studies of such procedures challenging.

The results of this study also add to the growing body of medical literature indicating that OAT should not be viewed simply as a revision cartilage procedure or "last-ditch" technique for large (>2 cm^2), full-thickness cartilage lesions. For instance, one study in which OAT was used as the primary and initial treatment reports a continued OAT survivorship of 89.5% at 5 years and 74.7% at 10 years, indicating its use as the index treatment procedure may be appropriate (9). Others have shown that previous subchondral marrow stimulation techniques do not affect the outcomes of OAT when comparing patients who received marrow stimulating techniques prior to OAT with patients who did not (10). This study further demonstrates that previous cartilage repair surgeries do not affect primary OAT outcomes, in comparison to ACI, in which previous marrow stimulation prior to ACI results in increased failure rates (11,12).

Regardless of a prior knee surgery's effect on OAT outcomes, many other advantages of OAT exist, including the ability to perform a single stage procedure and the restoration of a type II hyaline cartilage matrix that is physiologically more similar to native cartilage than fibrocartilage produced by microfracture (13). Furthermore, as the authors of Frank *et al.* point out, OAT has the advantage of addressing the osseous injury component of the cartilage lesion as well, making it an attractive primary treatment technique compared to microfracture and autologous chondrocyte implantation (ACI) for appropriately selected patients. It is important to consider that OAT is not a cure-all for large defects or defects with substantial subchondral bone involvement. In addition, some patient and lesion factors make OAT an unattractive option for cartilage repair at any stage. For example, in this study, patients with higher body mass index were shown to be at increased risk of failure. This may potentially be due to increased or improper loading on the OAT site, potentially resulting in a failure to preserve viable cells (14,15). The present study included a good assortment of athletes (60/180) and non-athlete patients alike, and still achieved a relatively low failure rate (13%), indicating its usefulness in patients with varying activity levels.

In addition, given the technical difficulty and the limited subchondral bone stock, patellar or anterior compartment cartilage lesions may remain difficult to treat using OAT. Reoperation rates and failure rates are reportedly higher and graft survivorship reportedly lower when OAT is used for treatment of patellar cartilage lesion treatment and this may limit its use to a salvage treatment technique for these lesions (10). Costs and other logistical drawbacks also exist related to OAT use. Defects and their grafts must be precisely and appropriately sized, a steep learning curve is required to perform the procedure successfully and to limit chondrocyte death, and the limited chondrocyte survival after graft retrieval and tissue banking processing and availability all may limit OAT use.

Frank *et al.* shed light on another important component of the cartilage repair treatment algorithm; what outcomes can be expected in failed OAT procedures that progress to knee arthroplasty? In this study, failed OAT patients (13% of the total study population) continued to have poor outcomes with revision surgery, including arthroplasty. In addition, others have corroborated the notion that patients who have failed outcomes after cartilage repair are at increased risk for failed outcomes after subsequent arthroplasty. For example, Steinhoff *et al.* report a rate of 31.4% failures at 9.2 years for total knee arthroplasties performed after failed OAT procedures (16). Another study reported a 15% failure rate at 3.7 years for arthroplasty after failed cartilage restoration (17). The reason for this relationship is likely multifactorial. Functional demands on implants may also play a role in future arthroplasty failure after failed cartilage restoration procedures. For example, younger patients may necessitate a greater demand on implanted components leading to higher failure rates. However, current data suggests this is not the entire story, as higher knee arthroplasty failure rates in patients with a history of failed cartilage restoration persist despite comparison to age/BMI/gender matched knee arthroplasty controls without prior cartilage restoration procedures (17). Psychological overlay or patient psychological factors may also play a role in suboptimal patient recovery and subsequent treatment success (18). Measures of patient self-motivation, self-efficacy, and optimism have all been shown in to impact compliance and patient symptomology (19). In addition, noncompliance and/or poor pain tolerance may also explain at least in part why patients with poor OAT outcomes go on to have poor knee arthroplasty outcomes.

Another important point to consider from this study is the finding that meniscus allograft transplantation (MAT), high tibial osteotomy (HTO), or distal femoral osteotomy (DFO) all did not predict failure when done in conjunction with OAT. This is not a surprising finding, as these procedures aim to correct underlying structural conditions that would increase loading on cartilage (malalignment or meniscal deficiency). What is surprising is that MAT/OAT did not have a higher reoperation rate than OAT alone, as reoperation after MAT alone has been reported to be as high as 32% (20). Indeed, others have reported reoperation rates as high as 54% for OAT with concomitant MAT (21). This may be in part due to surgeon experience and training as it relates to advanced cartilage repair procedures such as OAT. In this study, the low failure rate of 13% and overall complication rate of 3.3% may represent 'idealized' outcomes for OAT, as this surgeon performs a high volume of these procedures and results may not be generalizable to the greater cartilage restoration surgeon community.

The authors report a 37% reoperation rate and this is not unexpected as high reoperation rates are common among cartilage restoration procedures as a whole. Reoperation after microfracture has been reported to be as high as 29% and after ACI as high as 33% (22,23). In this study, 91% of reoperations (37% overall reoperation rate) were for limited debridement of mild synovitis, scar tissue, or degeneration of the host cartilage edge adjacent to the allograft tissue. Given the high potential for re-operation after OAT and/or OAT/MAT procedures, it is essential for patients to be counseled pre-operatively about the potential to need a second, minor arthroscopic procedure after OAT.

In conclusion, the authors of this study shed light on several essential considerations related to cartilage restoration and OAT. Most importantly, they highlight a potentially critical shift in cartilage defect treatment where OAT should not necessarily just be considered as a salvage cartilage treatment technique. The study's data also help to address important gaps in knowledge related to outcomes of

OAT in conjunction with MAT or HTO/DFO. Due to the robust patient data included, their results should function as important realistic expectations to use when counseling patients about the risks and benefits of OAT procedures.

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Footnote

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