QUESTION | DOES CHONDRAL GRAFTING WORK? WILL IT EVER REPLACE A TRADITIONAL KNEE REPLACEMENT?

ANSWER |

While chondral grafting does work if you select your patient very carefully is it is unlikely to replace traditional knee replacement in the foreseeable future. I have focused on the latest literature regarding chondral grafting in preparing this article.

Articular cartilage does not heal or regenerate. We think that significant injuries to articular cartilage progress and result in degenerative arthritis of the knee but there actually are no natural history papers in the literature that prove this. Most natural history studies are based on patients with ACL and/or meniscal tears rather than of isolated chondral injuries.

We know that some patients who have isolated chondral lesions and end up with radiographic arthritis are able to live their lives with very few symptoms (Some are even able to play regular impact loading sports). Progression of the chondral lesion may depend on it's size and location, the status of the underlying bone, the presence of arthritis; and patient factors such as age, limb alignment, joint stability and body mass index.

Although articular cartilage injury is a common finding at the time of arthroscopy, the prevalence of treatable chondral lesions in appropriate patients is small (less than 5%). **Injuries that are appropriate for treatment are full-thickness lesions more than 2 cm2 in size in a patient <40 years of age.**

Articular cartilage lacks a direct vascular supply and nutrients are delivered via the synovial fluid instead. Diffusion of this fluid through the cartilage requires an intact solid matrix of cells. Progenitor cells which reproduce more quickly than standard chondral cells are contained beneath the calcified cartilage and might allow healing of an injury (This has lead to the thinking that cartilage injuries that penetrate the calcified tidemark may improve the chances of the injury repairing itself). The process results in fibrin clot formation, vascular ingrowth, and marrow cell migration and forms a fibrocartilage scar made of type I collagen. The newly formed tissue does not duplicate the molecular and ultrastructural anatomy of the normal cartilage matrix (or its biomechanical properties) and thus eventually fails. We know that partial thickness defects do not repair but it is not only the absence of access to the bone marrow cells that prevents the repair of these defects. There must be other mechanisms involved that we do not understand yet.

When we are trying to replace chondral cartilage with repair tissue we have to achieve 2 main goals. The first is to fill the defect void with a tissue that has the same mechanical properties as articular cartilage. The second is to promote successful integration between the repair tissue and the native articular cartilage. Experience tells us that in most people even a small defect caused by mechanical damage will degenerate over time and cause osteoarthritis (although we have not proven this in the literature).

Three main techniques have been developed to ‘restore’ cartilage to the damaged area. These are 1) Microfracture 2) OAT and 3) MACI.

The microfracture technique was introduced by Steadman and is often considered to be the first-line treatment

option for full-thickness articular cartilage defects because of its minimally invasive nature, technical ease, limited surgical morbidity and low cost. The lesion is débrided to stable, squared-off edges. The zone of calcified cartilage

is removed, and cortical penetration is achieved with an awl, causing medullary bleeding and clot formation.

Undifferentiated mesenchymal cells in the clot mature to yield a fibrocartilage repair tissue with some type II collagen that is of inferior stiffness and that has poorer wear characteristics than does normal hyaline cartilage. Limited weight bearing and continuous passive motion are described by Steadman as key elements in postoperative success but this is rarely adhered to in Australia. The literature shows clear improvement in knee function at 24 months but inconclusive durability beyond the 2 year mark. There is some evidence that MACI performed on an area that has been treated with microfracture does not work as well.

OAT (or OATS as it is called by Arthrex) or mosaicplasty involves harvesting viable, structurally intact cartilage and bone plugs from a “less valuable” portion of the knee joint and transplanting that material to the site of symptomatic cartilage injury. Rapid healing and incorporation of the bone plug occurs and the articular gaps fill with fibrous tissue. Provided that the donor plug is sunk flush with the articular surface and that it can match the articular contour, normal contact pressures have been shown to be achieved over the healed graft. A donor plug can be harvested to match the size of the defect (usually 10 mm), or multiple smaller plugs can be used to resurface larger lesions (ie, mosaicplasty).

There are many problems with this technique, including creating symptoms in another part of the knee, the fact that thin articular cartilage is being used to replace thick cartilage and the fact that relatively flat cartilage is usually placed on a very rounded surface.

ACI involves the harvest of chondrocytes (200 to 300 mg) from a so-called nonessential portion of the knee in an initial biopsy procedure. This takes far less material than that required for OATS. The specimen is transported to a laboratory, where it is processed and seeded onto a membrane. The final medium of viable chondrocytes is then implanted on the prepared defect surface in a second procedure. The recovery phase includes a period of restricted weight bearing and use of a continuous passive motion device. The new cartilage that forms contains components of normal hyaline cartilage with similar morphology. Unfortunately the superficial layer is fibrocartilaginous and does not have the same mechanical properties of native cartilage (often called hylaline like cartilage).

ACI has yielded good to excellent results up to 7 years of follow up. At a minimum 3-year follow-up, outcomes were found to be better with ACI than with débridement alone, independent of lesion size.

Generally speaking younger, more active patients have better outcomes in all of these groups. Larger lesions seem to fare better with ACI and OATS than with microfracture but no correlation is seen between the histologic appearance of the repair cartilage and the clinical outcome. Several studies have shown that about 75% of patients have less pain after their procedure than preoperatively with a low failure rate. There seems to be little difference between ACI and microfracture at 2 years (except for very large lesions).

The literature does not show a clear outcome benefit for either ACI or OAT over microfracture. The best level IA evidence available does not demonstrate a difference in outcome between ACI and microfracture at an average follow-up of 5 years. A Cochrane database review evaluating four randomized controlled comparative ACI studies involving a total of 266 patients concluded that there was no evidence to suggest a difference in clinical outcome between ACI and other interventions. The conclusion drawn is that due to a lack of superiority of any one treatment, microfracture should be considered the first line therapy given its ease (one-stage procedure) and affordability relative to ACI. Future research may need to focus on a combination of biodegradable scaffolds and autologous cells to produce a mechanically functional hyaline repair tissue. Research also needs to focus upon promoting successful lateral integration between repair tissue and remaining cartilage. A combination of improved surgical instruments to minimise cell death at the wound margins and research to promote remodelling at the wound edge may enable successful predictable integration to occur.

Rehabilitation following **ANY** articular cartilage repair procedure is long and demanding. This varies with the size and location of the lesion as well as anything else that was required at the operation such as a high tibial osteotomy. There are many variations in rehabilitation protocols so it is not possible to discuss specific guidelines in this article.

Using Stem Cells for Cartilage Regeneration

Mesenchymal Stem Cells (MSC) are stems cells that have the ability to repair and regenerate tissue. The stem cells can be harvested from the patient. Scientists are working on ways to culture and expand the cells in vitro into useful population sizes. It is hoped that the grown tissue can be reintroduced to the damaged cartilage and help repair the damaged tissue. Returning to the question that was asked of me: In the short term knee replacements are here to stay but in the longer term perhaps this or some other gene modification therapy may be the way of the future.

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