Current Techniques of Chondral Resurfacing: Evidence-Based Results

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Abstract

Articular cartilage lesions are common, but difficult to treat with native hyaline cartilage having original histopathological, biochemical, and biomechanical properties. In the relevant literature, a spectrum of treatment options is present, and is summarized as; chondroprotective, chondrofacilitation, and chondrorestoration / resurfacing. In general, resurfacing methods can be classified as biological, and implant-related options. But the best treatment option is still controversial, in respect to the best current available evidence in terms of histological healing, biomechanics, and clinics. In the current era, systematic clinical approach, and careful selection of the patient, and lesion - considering the philosophy, and experience of the surgeons, and the availability of the implants- are of utmost importance for the proper management of the articular cartilage lesions, with the concomitant evaluation of lower extremity alignment, ligamentous stability, and meniscal integrity. Beside operative options, non-operative options should not be forgotten as first line treatment in symptomatic patients, without mechanical symptoms. As a future prospect, higher level of evidence studies are warranted, in order to make reliable, accurate, and relevant conclusions to ameliorate, and guide our systematic clinical approach for the articular cartilage lesions.

Keywords: Cartilage; chondral; osteochondral; lesion; biological resurfacing; implant resurfacing

Introduction

The famous quote of William Hunter “to be a very troublesome disease; that it admits of a Cure and more Difficulty that a carious Bone; and that, when destroyed, it is never recovered.” has been challenged by in-vitro, and in-vivo chondrogenetic studies in the historical perspective from subchondral drilling to advanced tissue engineering [1]

The articular cartilage lesions are frequently observed in general population (16 %), athletes (36 %), and during arthroscopic procedures (% 63); as partial or generalized, as partial or full thickness lesions, mainly due to trauma, ischemia or degeneration [2-4]. In clinics, they are most frequently observed in the knee joint, in the medial femoral condyle, and mostly as asymptomatic lesions.

Hyaline cartilage is the most frequent type of cartilage in the human body [5]. The articular cartilage -which contains hyaline cartilage- has the subsequent unique properties: avascular, aneural, and alymphatic. The subchondral bone is important as a strong mechanical support, and contains mesenchymal stem cells, which are important for the healing process. The continuous complex interactions between articular cartilage, and subchondral bone lead to the use of the term “osteochondral unit”, recently [6-9]. From another aspect, in-vivo chondrogenetic properties of the synovium was defined as “cartilage-synovium tropism” [10]. On the other hand, the joint synovium is a critical determinant of articular cartilage fate in inflammatory joint diseases [11]. Moreover, peritoneum, and omentum were also found as in-vivo chondrogenetic natural reservoirs [12].

The articular cartilage lesions are important in various aspects of basic, and clinical sciences; increasing frequency, pain & functional loss leading to interruption of daily living, increased risk of osteoarthritis, unfavorable economical, and social effects, no ideal treatment resulting in “original hyaline cartilage” with native histomorphology, biochemistry, and biomechanics, and no consensus in the current treatment methods [13-15]

Clinical Evaluation & Classification

The clinical evaluation of the articular cartilage lesions in the knee joint requires
a systematic approach which includes careful evaluation of patient history findings (including the symptomatology, activity level, and the expectations of the patients, etc.), physical examination findings (including alignment in inspection, painful areas, and provocative tests on palpation, range of motion, muscular strength, ligamentous status, neurovascular status, patellar examination, and examination of the contralateral side etc.), and findings on diagnostic imaging techniques (Plain radiography, Magnetic Resonance Imaging (MRI), and Computed Tomography (CT)). (Frank 2018) Articular cartilage lesions are commonly classified according to the Outerbridge, and more recently to the International Cartilage Repair Society (ICRS) Classifications. (Outerbridge 1961, www.cartilage.org)

**Management**

In general, the management of articular cartilage lesions aim to decrease pain, to increase function, and quality of life of the patients, and to prevent or delay the necessity to perform total joint arthroplasty. In this respect, the management can be summarized mainly as chondroprotective, chondrofacilitative, and chondrorestorative / resurfacing (biological or implant) modalities (Murray 2016). Considering the age; nonoperative methods or biological resurfacing for patients < 35 years old, nonoperative methods or biological or implant resurfacing for patients between 35-65 years old, and nonoperative methods or total joint arthroplasty for patients > 65 years old, can be selected. Chondroprotective, and chondrofacilitative non-operative methods (such as activity modification, injury prevention and rehabilitation programs, weight control, analgesics & non-steroid anti-inflammatory drugs (NSAIDs), various oral preparations including glycosaminoglycans, intraarticular injections as viscosupplementation, corticosteroids, and orthobiologics) are not curative, and have been preferred for only the relief of symptoms. (Poddar 2017) In recent years, biological injections (platelet-rich plasma, stem cells, and bone marrow aspirate concentrate) have been popularized with some important advantages; minimal invasiveness, relative low cost, and safety profile, isolated / combined use, faster healing process, and successful short term clinical results. (Kreutler 2017, Goldberg 2017, Kennedy 2018, Frank 2018, Cotter 2018) But, as the controversies on preparation methods, technical aspects, donor site diversities, optimal concentration, and dose, and the low level of evidence on long-term usage, necessitate comparative long-term
further studies in the near future. As these lesions are mostly asymptomatic in clinics due to aforementioned unique properties of the articular cartilage, clinical suspicion is of utmost importance in the treatment approach, which should be patient-, and lesion-specific. This part will mainly focus on the resurfacing methods - without diving into technical details- by giving special emphasis to the best available current evidence. Resurfacing strategies can be classified in two major categories: biological, and implant resurfacing.

**Biological Resurfacing**

Bone marrow stimulation techniques (e.g. microfracture, nano fracture etc.), osteochondral autograft / allograft transplantation, autologous chondrocyte implantation techniques, and tissue engineering techniques (e.g. cellular, scaffolds etc.) are among the most commonly used biological resurfacing techniques.

Microfracture, which is the most frequently used technique for symptomatic full-thickness, small (<2-4 cm²) cartilage defects nowadays, has been augmented biologically by the additional use of cells, scaffolds, and growth factors, so called "microfracture plus". (Albright 2017, Sommerfeldt 2016) The advantages of this technique are as follows; minimal invasive, easy application, cheap, cost-effective, successful clinical results at short term. (Kowalczuk 2018, Schorck 2017, Aae 2018) On the other hand, it also has some disadvantages; histopathological healing with fibrous cartilage, biomechanically inferior, only indicated for primary application, increased risk of subchondral injury, decreased clinical success at long-term. (Sommerfeldt 2016, Albright 2017) In a recent systematic review of Arshi A et al. it was emphasized that the level of evidence to make definitive conclusion on the efficacy of microfracture plus is low, individual trials report both equivalent, and superior clinical outcomes compared with microfracture alone. (Arshi 2018) Moreover, second generation needling techniques so called "nano fracture" has been emerged for deeper perforations with smaller diameter, and minimal injury to the subchondral bone. (Zedde 2017) But, it is necessary to observe the long-term results before routine use.

Osteochondral transplantation can be performed with autografts, and allografts. Firstly, osteochondral autograft transplantation so-called "mosaico plasty" is generally used for active patients with small to medium (<4 cm²) focal, grade III or IV chondral or osteochondral lesions of the knee joint, with the subsequent advantages; single stage procedure, restoration of hyaline cartilage, and relatively easy rehabilitation. (Sherman 2017) Donor site availability and morbidity, technical difficulties, joint line incongruence, integration problems, and conflicting results are its disadvantages. Secondly, osteochondral allografts are reasonable options for larger lesions (>4 cm²) with subchondral bone loss, as a single procedure with desired shape, and size. (Wydra 2017) But, the disadvantages are as follows; availability, high cost, shelf-life, technical difficulties, transmission of disease, immunological reaction, durability and integration problems. Another emerging option is particulated articular cartilage particularly in the juvenile allograft form, which seems promising with increased restorative, and proliferative potential as a single procedure; graft hypertrophy, technical difficulties, and limited experience are the main drawbacks of this procedure. (Riboh 2015)

Autologous chondrocyte implantation (ACI) has been developed from the first generation (periosteal patch - pACI) to the second generation (type I/III collagen membrane – cACI), and more recently to the third generation (matrix/scaffold-based polymers - mACI). (Welch 2016, Basad 2015) ACI, which is usually indicated for medium to large (>2 cm²) osteochondral defects as a primary or secondary procedure, allows healing with hyaline-like tissue, and biomechanical advantage. (Hinckel 2017) The main disadvantages are listed as below: two-stage procedure, joint line incongruity, donor site morbidity, expensive, technical difficulties, late weight bearing and rehabilitation.

In the last years, osteochondral tissue engineering has developed tremendously in the historical perspective of cartilage resurfacing procedures. Basically, tissue engineering approaches use the combination of the four requirements: (Panseri 2012, Vinatier 2016, Armiento 2018, Safran 2008)

1. **Scaffolds** – Osteochondroductive
2. **Bio factors / Signals** - Osteochondroinductive
3. **Cells** – Osteochondrogenic
4. **Stable and suitable fixation**

Although good clinical results were reported by the use of tissue engineering products, two issues are still present to be resolved; functional regeneration problem, and ongoing integration process even in the first year. (Mathis 2018)

In a recent analysis of a large United States commercial database, reoperation rates for microfracture, osteochondral allograft transplantation, osteochondral autograft transplantation, and ACI were reported as 92.3 %, 3.4 %, 2.9 %, and 1.4 %, respectively. (Frank 2018) Return to sports rates (%) & mean time of return (months) for osteochondral autograft transplantation, osteochondral allograft transplantation, ACI, and microfracture were reported as 89-93 & 5.2-7.1, 88 & 9.6, 82-84 & 11.8-16, and 58-75 & 8.6-9.1, respectively. (Campbell 2016, Krych 2017) Although microfracture was reported to be most frequently used, and the most cost-effective procedure among biological resurfacing procedures, the
decision for the contemporary management decision for the articular cartilage lesions depends on the factors related with lesions, patients, availability of the facility’s conditions, and surgeon’s experience and philosophy. (Kowalczuk 2018, Schrock 2017, Farr 2011)

**Implant Resurfacing**

Implant resurfacing of articular cartilage lesions is divided into two major categories: metal and non-metal joint surfaces. Looking back to the historical evolution, implant resurfacing of focal articular cartilage injuries began with the experimental study of Kessler et al. in 1980. (Kessler 1980) After the year 2000, newer clinically applicable implants were introduced sequentially; HemiCAP® and UniCAP® by Arthrosurface Inc. USA, Episealer® by Episurf Medical Sweden, and BioPoly® by Schwartz Biomedical Company USA.

The advantages of implant resurfacing are as follows; short learning curve, minimal morbidity, preservation of soft tissues and bone stock, protection of the native anatomy and biomechanics, arthroscopic-assistance, daily practice, early weight bearing and rehabilitation, sole or combined procedures, and easy conversion to total joint arthroplasty.

The lack of systemic, synovial, and rheumatoid disorders in the patients, the focal characteristic of cartilage lesion, alignment, stability of the soft tissues and joints, and adherence to the surgical technique are extremely important for the application of implant resurfacing. Although they are mainly used in the knee joints, they can also be used in various joints (e.g. shoulder, hip, ankle etc.) for focal cartilage defects, avascular necrosis, or osteoarthritis, as primary, secondary salvage (revision of biological resurfacing) or combined procedures, acting like a bridge between biological resurfacing, and conventional joint arthroplasty (Bollars 2012, Bilge 2015, Bilge 2015 Apr, van Bergen 2013, Schuster 2018, Miniacci 2014) (Figure 1, 2, and 3).

The rates of conversion to total joint arthroplasty in 3-10 years were reported to be 22 %, 25 %, and 28 % in femoral condyle, femoral head, and patellofemoral joint, respectively. (Fuchs 2018, Floerkemeier 2017, Laursen 2017) In a comparative study, clinical results of the biological and implant resurfacing in the femoral condyles for 2 years of follow-up were reported to achieve similarly high satisfaction rates, comparatively. (Pascual-Garrido 2017)

**Conclusion**

The focal articular cartilage lesions have been increasingly encountered in clinics. The clinical approach for the management of these lesions have evolved tremendously from drilling to the advanced tissue engineering biological resurfacing approaches, and defect-filling implant resurfacing techniques. Recent efforts are primarily towards biological resurfacing, and secondarily filling the defects with implant resurfacing. Both approaches have been evolving, and have their specific advantages, and disadvantages. As a future prospect, relatively newer techniques, such as gene therapies, and three-dimensional (3D) printing to restore anatomical geometry with regeneration of the repair tissue similar to the original articular cartilage, have been investigated for their routine clinical use. Finally, as mentioned in the relevant literature; the cartilage resurfacing is still an unresolved enigma. (Dahlgren 2016)

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