Autologous Costal Cartilage Graft—A New Method to Treat Articular Cartilage Defects: Case Report and Note of Surgical Technique

Antonio Gigante1 Marco Cianforlini1 Luca Farinelli1 Riccardo Giroto2 Alberto Aquili1

1Clinical Orthopaedics, Department of Clinical and Molecular Science, Università Politecnica delle Marche, Ancona, Italy
2Maxillofacial Surgery Unit, Azienda Ospedaliero-Universitaria Ospedali Riuniti, Ancona, Italy

Address for correspondence Antonio Gigante, MD, Clinical Orthopaedics, Department of Clinical and Molecular Sciences, Università Politecnica delle Marche., Via Tronto 10/A, 60126 Ancona, Italy (e-mail: a.gigante@univpm.it).

Introduction

Full-thickness articular cartilage defects do not heal spontaneously. Several techniques have been developed to address this issue, but none resulted in the restitutio ad integrum of the articular cartilage. The most frequent sites of chondral lesion in the knee are medial femoral condyle and patella. The patellofemoral lesions are characterized by outcomes that are generally worse than those of tibiofemoral ones. To date, it has been well recognized the chondrogenic potential of rib perichondrium, and costal cartilage grafts have been extensively used in reconstructive surgery. Considering the need to find a gold standard technique to restore articular defect, we developed and here described a new technique to repair cartilage lesions of the knee using autologous costal cartilage graft with its perichondrium. This innovative surgical approach can be used to treat full thickness articular defects using autologous hyaline cartilage, making it possible to cover wide defects. This one step technique is low invasive, not technically demanding with minimal donor site morbidity and it has low costs. The long-term clinical efficacy of the method remains to be evaluated.

Abstract

Full-thickness articular cartilage defects do not heal spontaneously. Several techniques have been developed to address this issue, but none resulted in the restitutio ad integrum of the articular cartilage. The most frequent sites of chondral lesion in the knee are medial femoral condyle and patella. The patellofemoral lesions are characterized by outcomes that are generally worse than those of tibiofemoral ones. To date, it has been well recognized the chondrogenic potential of rib perichondrium, and costal cartilage grafts have been extensively used in reconstructive surgery. Considering the need to find a gold standard technique to restore articular defect, we developed and here described a new technique to repair cartilage lesions of the knee using autologous costal cartilage graft with its perichondrium. This innovative surgical approach can be used to treat full thickness articular defects using autologous hyaline cartilage, making it possible to cover wide defects. This one step technique is low invasive, not technically demanding with minimal donor site morbidity and it has low costs. The long-term clinical efficacy of the method remains to be evaluated.

Keywords

► cartilage repair
► patella
► costal graft
► rib perichondrium

Irrespective of the surgical technique used, hyaline cartilage has been obtained only in selected cases, without restoring articular cartilage microarchitecture.5,12,13

After the medial femoral condyle, the patella is the second most common location in the knee for the occurrence of chondral lesions.14 Furthermore, despite the wide selection of technique available, it has been well established that in the patellofemoral compartment outcomes are generally worse than in the tibiofemoral joint.15 For these reasons, the best technique remains to be addressed; the main goal in managing patellar injuries should be to restore the cartilage surface with grafts of hyaline cartilage to re-establish the biomechanical properties of the tissue restoring knee function. The use of autologous costal cartilage graft for the treatment of articular defects of the knee in humans has never been
described before. Only limited and promising results have been obtained by animal models with costal fragments. Indeed, Du et al sliced rib cartilage into 3- to 5-mm fragments and then harvested cartilage grafts in the rabbit knee lesions in one step technique.

Considering this imperative, we developed a new technique for repair articular cartilage defect using autologous costal cartilage graft with its perichondrium.

The main elements contributing to the rationale for this choice were: (1) the graft is autologous and of hyaline nature; (2) the perichondrium of the graft has chondrogenic potential; (3) the costal graft is widely used in reconstructive surgery and usually it has a low donor site morbidity; (4) the graft may be properly sized to cover large and full-thickness articular defects; (5) the method is “one-step” and has a low cost.

Case Description

In September 2017, a 15-year-old male was referred to the Department of Orthopaedics of the Polytechnic University of Marche (Italy) for anterior knee pain. Symptoms were exacerbated by going downstairs, running, jumping, and squatting. In addition, the patient described the movie sign, in which anterior pain was increased after prolonged sitting. No signs of patella instability were revealed. The Lachman test, anterior drawer test provided negative results. No signs of meniscal injuries, cruciate ligaments ruptures, or osteoarthritis of both patellofemoral and tibiofemoral joint. The defect was classified grade III according to ICRS classification.

The unique anatomy of the patellofemoral joint makes surgical exposure to the patellar articular surface difficult to achieve arthroscopically; thus after the arthroscopic diagnosis, we preferred an arthrotomy through a lateral parapatellar incision that allowed a direct and perpendicular approach to the patellar lesion. With the patella everted, clear visualization of the defect was possible (►Fig. 1).

Once measured the patellar defect by the ruler, we moved to the thorax to harvest the costal cartilage graft. A skin incision of approximately 3 cm was made along the major axis of the seventh rib in proximity of the right costosternal joint (►Fig. 3).

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Separation of the overlying muscles was performed to expose the rib, a subperichondrial dissection of the seventh costal cartilage with delivery of the distal part of the rib was done and the required length was harvested. A 15-blade

Fig. 1 (A) Cartilage defect of the medial facet of the patella. (B) The lesion after debridement.
scalpel was then used to make incisions both at the medial and at the lateral aspect of the sized graft. An elevator was then used to remove the graft. The incisions should extend through the cartilage but not violate the underlying perichondrium. Indeed, special attention should be laid to preserve as intact the three sides of the rib (Fig. 4).

The graft was carefully shaped and impacted into the defect. Its height matched with that of the neighboring cartilage, because an uneven articular surface could alter the biomechanical functionality of the patellofemoral joint.15 The graft was positioned with the perichondrium facing toward the trochlear groove (Fig. 5).

To fix the graft in compression, we applied two nonabsorbable sutures through the graft; then we performed four holes across the patella. Subsequently, we put the free ends of the sutures through the patella and we tied two knots in the surface opposite to the patellofemoral joint. To ensure the graft in the lesion, we passed two absorbable sutures between perichondrium and the neighboring cartilage. After the implantation of the graft, the tourniquet was removed.

Lastly, we filled the borders of the implant with fibrin glue to make the surface smooth and to strengthen the graft. A drainage has been introduced to avoid local hematoma and then it was removed in the second postoperative day. The incisions were closed with absorbable sutures on the fascia and subcutaneous planes and with nonabsorbable sutures for the skin.

**Postoperative Care**

When he was discharged from the operating theater, the affected leg was immobilized in a brace in full extension for 48 hours; then continuous passive motion was used for the

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**Fig. 2** Size of the chondral defect after microfractures.

**Fig. 3** Cutaneous scar at 3 months after surgery. The skin incision about of 3 cm was made along the major axis of the seventh rib in proximity of the right costosternal joint.

**Fig. 4** (A) The surgeon measured the size of the graft. (B) Schematic representation of costal graft (G, Graft; P, perichondrium).
first month after surgery. Weight bearing was not allowed for 4 weeks, the patient was allowed to walk with crutches without putting weight on the affected leg. Progressive weight bearing on the affected limb and active movement during physiotherapy were allowed from the second month following surgery.

Discussion

We developed this technique on the basis of previous histological, immunohistochemical, and ultrastructure characterization of costal cartilage.

First, from a biological point of view, the costal cartilage represents the main source of hyaline cartilage in mammals and it is characterized by histological similarities to the articular cartilage.\(^2^3\) Furthermore, it is surrounded by rib perichondrium, whose chondrogenic capacity was demonstrated by Skoog et al in 1972.\(^2^4\) Summarizing, the graft presents the histochemical (hyaline) and microarchitectural features close to the articular cartilage; thus, it could support the biomechanical loading imposed by the joint with the peripheral perichondrium that might promote the integration mechanism. Moreover, the use of an autologous tissue avoids any adverse reactions.

Second, from a surgical point of view, it is easy to fit the costal graft in the lesion; in case of extensive or multiple defects, multiple costal cartilage grafts might be harvested from the same incision; it is a noninvasive and low invasive technique with minimal donor site morbidity. Lastly, the method proposed may be efficient in cost-benefit terms, because it is a “one step” and low cost procedure.

On the other hand, the method presents some critical issues. We do not know if the borders of the costal graft may be integrated in the neighboring cartilage and if the graft may be efficiently anchored to the bone through endochondral ossification. Moreover, the long-term clinical efficacy of the method remains to be evaluated.

Conflict of Interest

None declared.

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