Uses of autologous chondrocyte implantation in treatment of osteochondral defects of the talus

Essay

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BY

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Abstract

Osteochondral lesions of the talus can cause functional impairment of the ankle joint, with inconvenience for patients and decrease their vital activity. Joint cartilage defect is a cause of pain and swelling in lower limb, regardless whether loaded, or at rest.

Many methods are used to treat these injuries e.g. drilling, microfracture, autograft & allograft transplantation.

Interest has focused on the treatment of vast and deep cartilage lesions with techniques such as, the use of autologous chondrocyte implantation (ACI) specially after emerging of the scaffold technique modification or matrix-induced autologous chondrocyte implantation (MACI).

KEYWORDS:

Osteochondral defects (OCD) of the talus- Autologous chondrocyte implantation (ACI) - Matrix-induced autologous chondrocyte implantation (MACI).

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List of abbreviations

- **ACI:** autologous chondrocyte implantation.
- **ACI-C:** autologous chondrocyte implantation collagen membrane covered.
- **ACI-P:** autologous chondrocyte implantation with periosteal flap.
- **ACT:** autologous chondrocyte transplantation.
- **AOFAS:** American orthopaedic foot and ankle society.
- **COMP:** cartilage oligomeric protein.
- **CPM:** continuous passive motion.
- **CT:** computed tomography.
- **ECM:** extra cellular matrix.
- **GAG:** glycosaminoglycan.
- **HEPES:** N-(2-Hydroxyethyl) piporazine-N'-(2-ethanesulfonic acid)
- **K-wire:** Kirschner wire.
- **MACI:** matrix-induced autologous chondrocyte implantation.
- **MPa:** mega Pascal (=9.87 atmospheric pressure).
- **MRI:** magnetic resonance imaging.
- **OAT:** osteochondral autograft transplantation.
- **OCD:** osteochondral defect.
- **OCL:** osteochondral lesion.
- **OLT:** osteochondral lesion of talus.
- **PBS:** phosphate buffered saline.
- **PSI:** pound per square inch (= 0.68 atmospheric pressure).
- **ROM:** range of motion.

Aim of the work

The aim of this work is to review the literature regarding treatment of osteochondral defects of the talus with autologous chondrocyte implantation and to discuss the topic as regard cartilage healing, clinical and radiological diagnosis, options of treatment of osteochondral defects including indication, technique, follow up and results of autologous chondrocyte implantation.

Introduction

Introduction

Osteochondral lesions of the talus are a known cause of chronic ankle pain. They are frequently found in the active population after ankle sprains. The terminology has its origins in 1856, when Monro first described the presence of cartilaginous loose bodies in the ankle joint. In 1888, Konig coined the term "osteochondritis dissecans" to describe spontaneous necrosis of subchondral bone and articular cartilage with loose body formation in the knee. In 1922, Kappis applied this term to describe similar lesions in the ankle joint. However, such a term implied an inflammatory disease process, leading to confusion. The term was revised in 1959 by Berndt and Harty who used the term "transchondral fractures of the talus". Several other terms have been used, including "osteochondral fracture" and "talar dome fracture", but currently, "Osteochondral lesion of the talus" OCL remains the most inclusive term to describe the problem. [1-5]

Whatever the etiology osteochondral lesions can cause functional impairment of the ankle joint with inconvenience for patients and decrease their vital activity. Joint cartilage defect is a cause of pain and swelling in lower limb, regardless whether loaded, or at rest. A limited potential for osteochondral defect healing may lead to ankle arthrosis. [5]

Articular cartilage is an avascular, aneural and alymphatic tissue that has limited repair capabilities compared with other mesenchymal tissues. Despite its highly specialized nature, hyaline articular cartilage repair product has the histological appearance of a fibrocartilaginous variant with mechanical properties that are inferior to those of the original tissue. Chondrocytes also have limited migratory ability and, as a result, the surrounding normal cartilage cells do not fill the defect. Chondrocytes have a transient but insufficient response to injury. They increase their

mitotic activity as well as their production of glycosaminoglycan (GAG) and collagen but only for a short period of time and to a limited degree. [6]

It is not completely understood which lesions will progress to arthritis if left untreated and which will not. The cartilage in the ankle is only 1 to 2 mm thick. It also has a small contact area of about 350 mm (compared with 1120 mm in the knee and 1100 mm in the hip). These factors make the ankle joint less able to adapt to small surface incongruities, leading to increased stress on the joint. [7]

Symptomatic osteochondral lesions of the talus can cause functional impairment of the ankle joint. Because of the poor natural history of these lesions without intervention, or with intervention such as debridement with or without drilling or microfracture of the subchondral bone, it is usually necessary to try to restore the cartilaginous surface to avoid early osteoarthritis and to improve joint function .[8]

Usually, in talar chondral defects, the subchondral bone is involved, and either osteosclerotic or cystic lesions make healing processes impossible. Considering non-operative treatment options Canale and Belding reported on 29 patients with 31 osteochondral lesions (OCLs) of the talus, their study found that with medial stage III lesions, operative and nonoperative results were equal. The lateral stage III lesions, however, did better with surgical management. [9]

Operative treatment options include debridement; microfracture and drilling such procedures are reserved for completely detached talar osteochondral lesions that are not amenable to internal fixation. These can be done open or arthroscopically, which entail mainly excision of the osteochondral fragment and curettage of the lesion’s surface to remove debris and devitalised tissue. [10]

Joint resurfacing by osteochondral autografts transplantation (OAT) or Mosaicplasty technique was originally developed to treat focal

cartilage defects of the femoral condyles of the knee and was subsequently adopted for the ankle. Only a circumscribed surface can be covered because of the limited number of suitable donor sites, and lesions of the talar shoulder can be difficult so treatment is limited to smaller defects of 2 - 4 cm^2. [11]

Allografts, although successful with some surgeons specially in covering large defects, impose limitations of donor availability, long duration of recovery, and associated complications such as immunogenicity challenge, limited chondrocyte viability and are associated with disease transmission. [12]

Autologous chondrocyte implantation (ACI) is currently indicated for focal, isolated defects and was first used to treat cartilage lesions of the knee. There is less donor site morbidity; perfect fit with the cartilage defect can be achieved, leaving no “dead spaces” in between. Histological studies have shown regeneration of the hyaline cartilage with a smooth surface. [13]

Interest has focused on the treatment of vast and deep cartilage lesions with techniques such as the use of autologous osteochondral grafts and autologous chondrocyte transplantation with a periosteal graft. [14]

Histology of cartilage & methods of repair

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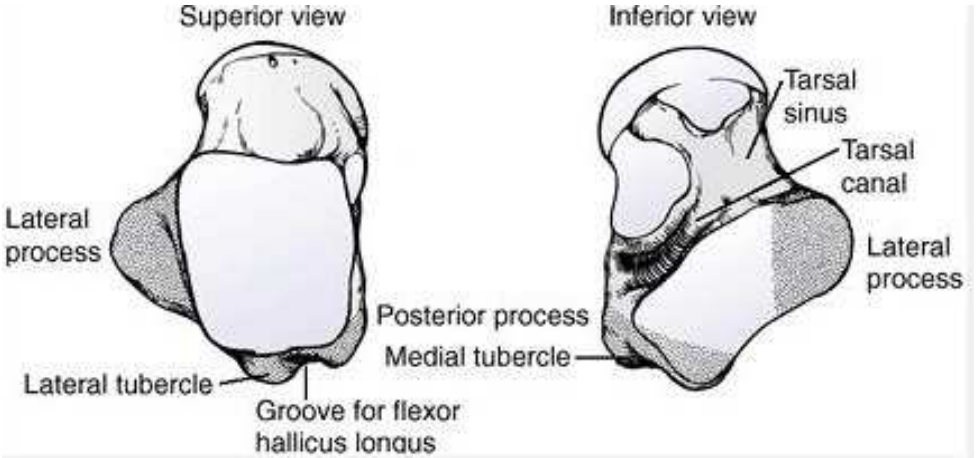
RELEVANT ANATOMY:

The talus consists of 3 parts: head, neck & body, the body of the talus is enclosed by a deep bracket-shaped socket created by the fibula and tibia. When viewed from above, the body of the talus is much wider anteriorly than it is posteriorly (Fig.1-1); As a result, the bone fits tighter into its socket especially in dorsiflexion. (15)

Articular hyaline cartilage covers approximately 60% of the talar surface (1-2cm) thick and there are no direct tendon or muscle attachments to the bone. (16)



A B

Fig (1-1): A- Superior B- inferior view of the talus (17)

The vascular supply to the talar body can be summarized as follows: (Fig 1-2) the artery of the tarsal canal is the most consistent major supplier of blood to the body of the talus. The deltoid artery the second major blood supply directly supplies blood to the medial one fourth to one half of the talar body, the artery of the sinus tarsi, supplies the lateral one eighth to one fourth of the talar body.(18)

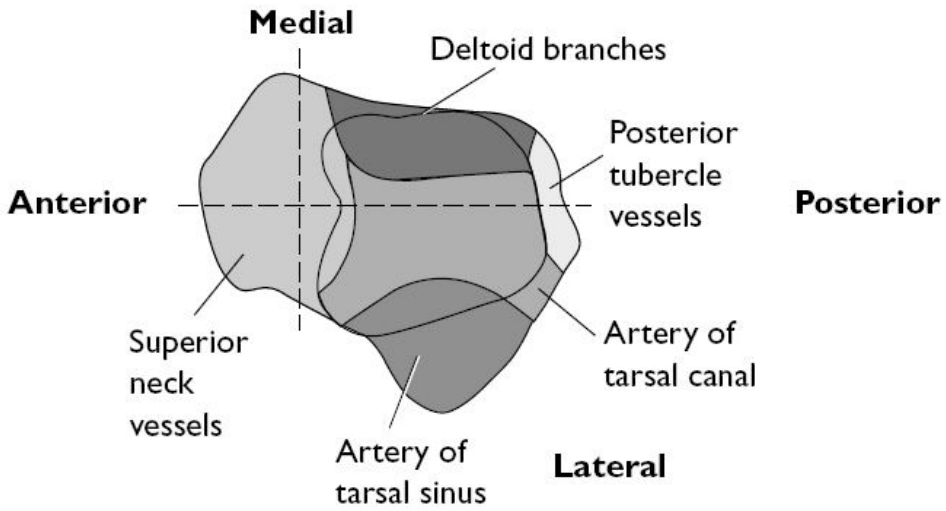


Fig (1-2): Internal vascularity of the talus superior view [19]

Histology:

Articular cartilage, the resilient load-bearing tissue that forms the articulating surfaces of diarthrodial joints, provides these surfaces with the low friction, lubrication, and wear characteristics required for repetitive gliding motion. It also absorbs mechanical shock and spreads the applied load onto subchondral bone. Articular cartilage (fig 1-3) consists primarily of a large extracellularmatrix (ECM) with a sparse population of highly specialized cells (chondrocytes) distributed throughout the tissue. [20]

The structure and composition of the articular cartilage vary throughout its depth (Fig 1-4), from the articular surface to the subchondral bone. The cartilage can be divided into 4 zones: the superficial zone, the middle or transitional zone, the deep zone, and the zone of calcified cartilage. [20]

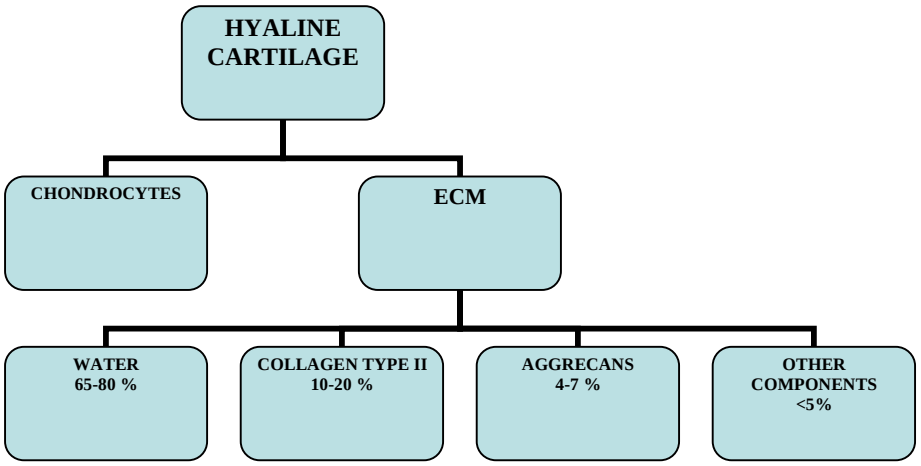


Fig (1-3): components of articular cartilage

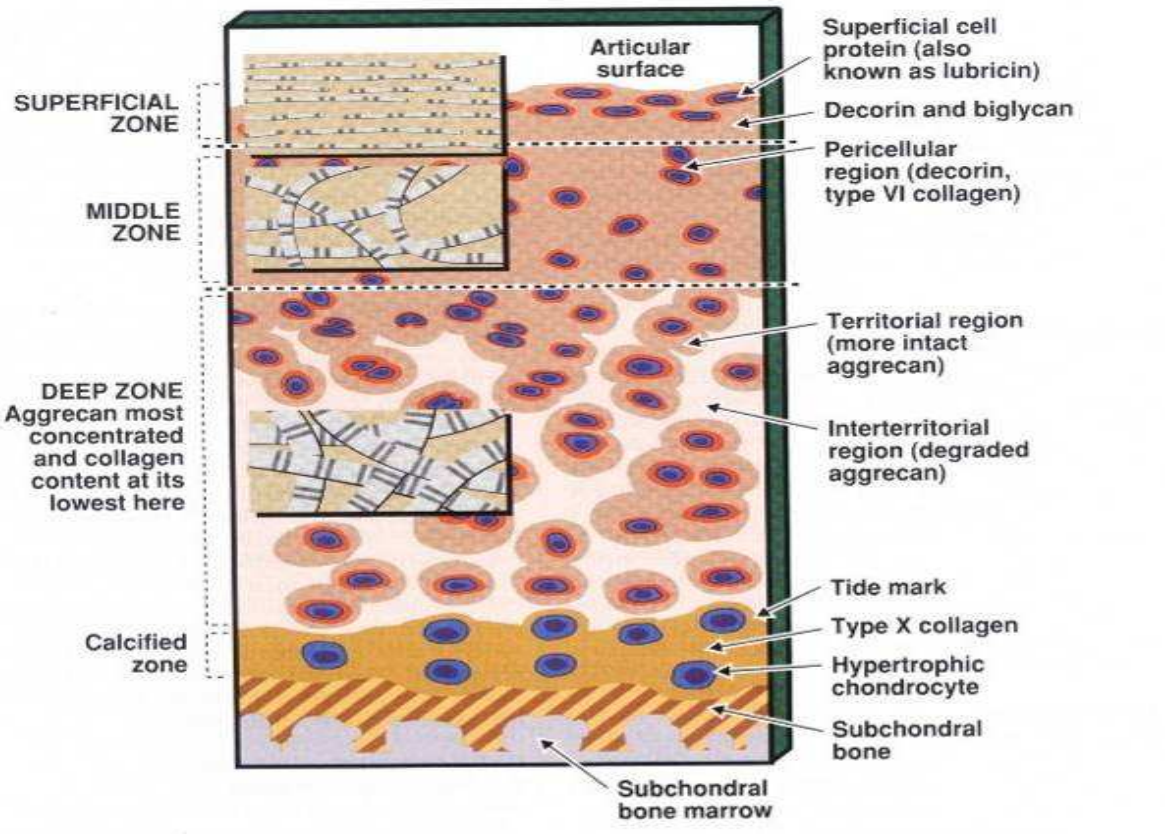


Fig (1-4): Diagrammatic representation of the general structure of human adult articular cartilage, showing the zones as well as the relationship with subchondral bone. [21]

I-Chondrocytes

The formation and maintenance of articular cartilage depends on the chondrocytes. They are responsible for the maintenance of the ECM. Chondrocytes are metabolically active and are able to respond to a variety of environmental stimuli such as soluble mediators, pharmaceutical agents & mechanical loads changes. All its actions take place under avascular and, at times, anaerobic conditions, with considerable variation in local pressure and physicochemical states. [20, 22]

II-Matrix Composition

The cartilage composition is determined primarily by the matrix. Normal cartilage has water contents ranging from 65% to 80% of its total wet weight (Fig 1-5). The remaining wet weight of the tissue is accounted for principally by 2 major classes of "structural" macromolecular materials: collagens and proteoglycans, also there are other molecules including lipids, phospholipids, proteins, and glycoproteins. [23]

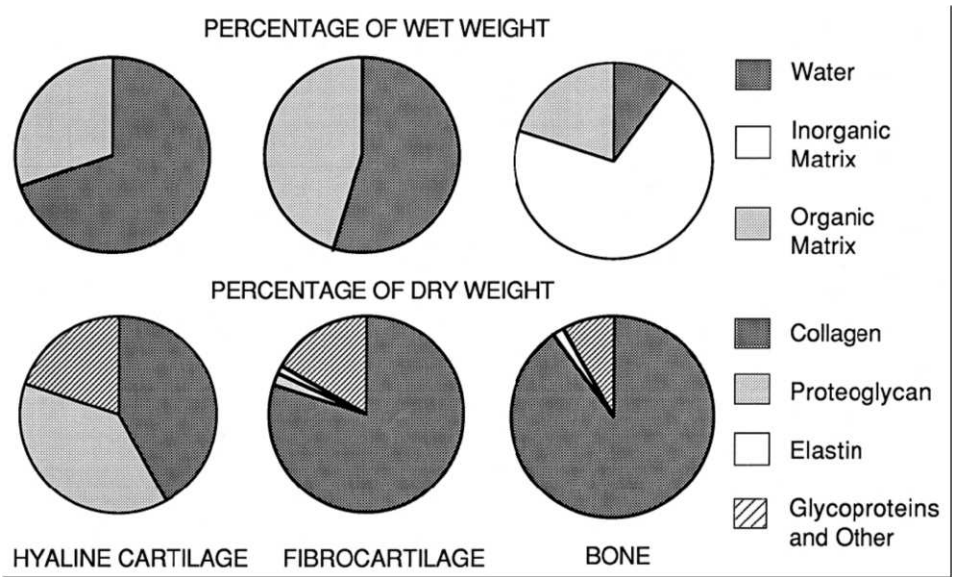


Fig (1-5): Composition of 3 classes of skeletal connective tissues: hyaline cartilage, fibrocartilage, and bone [20]