Comparison of cartilage self repairs and repairs with costal and articular chondrocyte transplantation in treatment of cartilage defects in rats

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Abstract

In our experiment, we tried to assess the potential of repair of full-thickness defects in articular cartilages of rabbit femurs. An artificially made, full-thickness defect in the rabbit's femoral patellar groove was created. The defects were divided into six groups. The reparative tissue was evaluated by macroscopic, histological, and immunohistochemical examinations. The reparative tissues in defects with transplanted chondrocytes, had mostly a hyaline-like cartilage appearance and were firmly attached to the surrounding normal cartilage. Only in the control group with periosteal flap and broken subchondral plate, there were signs of partial repair. Self repair of rabbit articular cartilage is very limited. Transplantation of chondrocytes, costal and articular, without differences between groups, is a very potential treatment, producing hyaline-like repair tissue with good histological results.

Key words: articular cartilage repair, costal and articular chondrocytes, transplantation.

Introduction

The intrinsic capacity of cartilage to self-repair chondral injuries is poor. Many different techniques to induce cartilage repair have been explored. Many, currently used, methods involve an introduction of chondrogenic cells into the defects [1, 2, 3]. Chondrogenic cell transplantation, held in place by a covering periosteal flap, produces a hyalin-like repair tissue [4, 5, 6]. In our experiment, we tried to answer the following questions: Is self-repair of articular cartilage possible? When does it occur? Is the self-repair comparable with chondrocyte transplantation?

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Materials and methods

Nine (9) New Zealand White male rabbits were used in the experiment. Defects were created on the patellar grooves of the rabbit femur. A culture of chondrocytes and surgical procedures were performed as described before [7]. The defects were divided into 6 groups: A) filled with costal chondrocyte transplantation and covered with a periosteal flap. B) filled with articular chondrocyte transplantation and covered with a periosteal flap. Control groups without chondrocytes: C) covered with a periosteal flap without breaking the subchondral plate. D) without periosteal flap, without breaking the subchondral plate. E) without periosteal flap, with the broken subchondral plate. F) with a periosteal flap, with the broken subchondral plate. The surfaces of the grafts were inspected for colour, integrity, contour and smoothness.

The histological staining with Safranin O, haematoxylin-eosin and Azan methods (azocarmine + anilin blue) were performed. For immunohistochemical analysis, specific antibodies against rabbit collagen type II (Novocastra) were used.

Results

The reparative tissue, in the defects with the transplanted chondrocytes, showed an appearance, similar to that of normal cartilage in all the groups. The defects were filled with a white, glossy and smooth tissue and were firmly connected to the adjacent normal cartilage. (Fig. 1ABCD). The defects in the control groups were filled with a red semitransparent tissue with dis-

Figure 1. Gross photographs of patellar groove of rabbit femurs, a complete incorporation of the repair tissue into the surrounding cartilage with clearly recognizable margins of the defect (A, B - costal, C, D - articular chondrocytes transplantation).

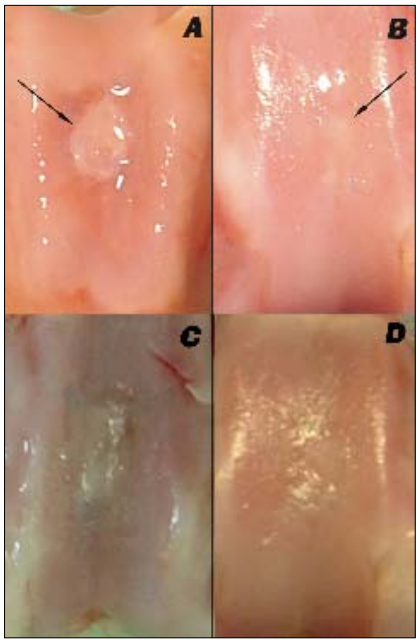


Figure 2. Gross photographs of patellar groove of rabbit femurs, partially filled by repair tissue (A- group E; B-group E; C-group C; D- group D).

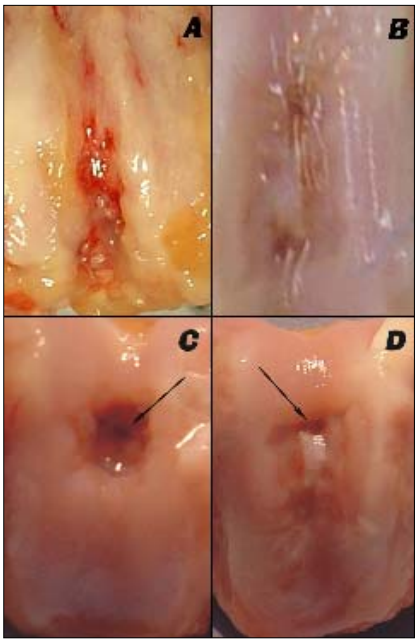


Figure 3. Photomicrograph of section of the reparative tissue with transplantation of costal chondrocytes, deep layers of scar tissue, at 4 weeks, showing numerous irregular groups of chondrocytes with abundance of the extracellular matrix. Safranin O staining, scale bar, 100 µm.

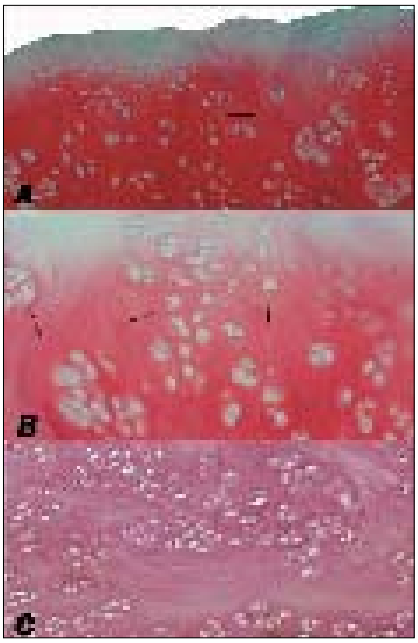


Figure 4. Photomicrograph of section of the reparative tissue with transplantation of articular chondrocytes (A, B), fibrocartilage (C). Safranin O staining, scale bar, 100 µm.

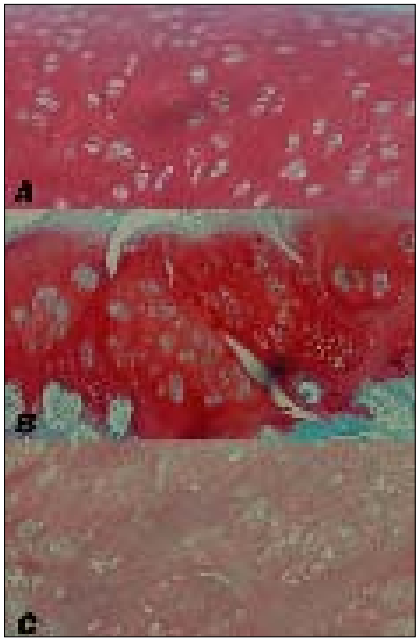


Figure 5. Photomicrograph of section of the reparative tissue with transplantation of costal chondrocytes, intense immunohistochemical positive staining for collagen II (B, C), healthy cartilage (A); scale bar 50 µm.

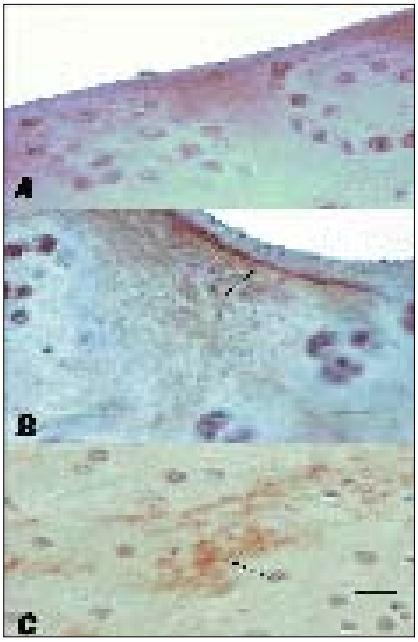
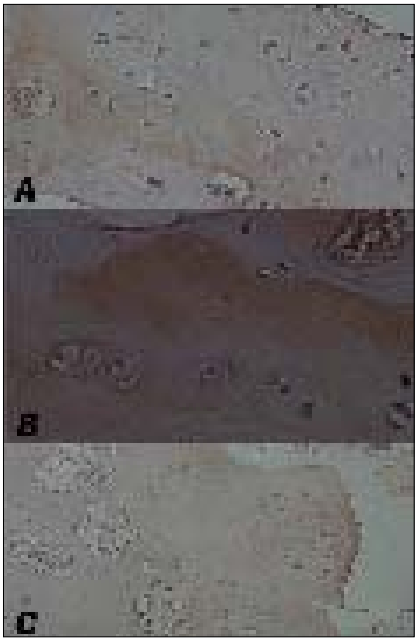


Figure 6. Photomicrograph of section of the reparative tissue, Group F- partial repair, scarce immunohistochemical positive staining for collagen II; scale bar 50 µm.



cernible edges and of very low compliance. Small fissures and fractures and loose attachments to the surrounding cartilage were present with no significant differences between groups (Fig. 2ABCD). The defects, transplanted with chondrocytes, were filled with newly formed tissues, firmly incorporated into the surrounding normal cartilage. Most of the defects were filled with a hyalin-like cartilage (Fig. 4, Fig. 5), resembling healthy cartilage. In some specimens, in varying localization, fibro-cartilage of lower hystological grade was present (Fig. 5C). The reparative tissue in the control groups, consisted mostly of numerous fibroblast-like cells, surrounded by many collagen fibres with a chaotic orientation. Its structure was characteristic of fibrous connective

tissue and did not show any significant changes between the groups. A positive immunohistochemical reaction with Collagen II antibody was observed in the repair tissue in each defect with chondrocyte transplantation. Staining distribution varied throughout the defects (Fig. 7BC). The immunopositive reaction in normal cartilage had a very similar appearance (Fig. 7C). Only in group F, the defects were covered with periosteum, with a broken subchondral plate and small islands of immunopositive tissue were present. Those places of incomplete repair were connected with a broken subchondral plate. No traces of immunopositive reaction were present in any of the other groups.

Discussion

Macroscopic observations of repair tissue in the defects with chondrocyte transplantation showed its good incorporation into the surrounding cartilage, which may be of higher importance than the quality of the tissue itself [8], protecting the surrounding normal cartilage from further deterioration [9]. Macroscopic observation in the control groups showed only a partial repair, with a slightly better outcome in Group F but still incomparable to that in the main groups. Those results are similar to findings of other authors [10, 11, 12]. Histological results in the two groups with chondrocyte transplantation, did not show any significant differences. Most of the defects were filled with hyalin-like tissue. In the control groups, only fibrous connective tissue was present. Positive staining with Safranin O, was present only in Groups A and B and showed an intensive production of proteoglicans in young cartilage [9]. Negative staining was present in all the control groups. Many authors have noticed that a partial regeneration of chondral defects can be induced by cells, either migrating from the surrounding tissue or from subchondral bone marrow. However, those cells were not able to induce healing, comparable with that, caused by transplated chondrocytes. That was confirmed by our control group. Repair tissues in empty defects, covered with a periosteal flap with a broken subchondral plate, were limited to small areas, adjacent to the subchondral defect and were of lower macroscopic and histological quality. Immunonegative reaction with Collagen II antibody was observed in every other control specimen. Our findings confirmed those by Kajitani et al [13]. According to this author, periosteal flap might act only as a mechanical barrier to prevent leakage of grafted chondrocytes without beneficial humoral or cellular effect on the formation of reparative tissue. Articular cartilage repair with chondrocyte transplantation gives good repair in terms of macroscopic and histological evaluations. Self-repair is very limited and can not give sufficient healing of the defect, even with the defect spreading under the subchondral plate.

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