ORIGINAL PAPER

The arthroscopy-histological criterion link in endoscopic "repair" treatment of chondral and chondralbone lesions of the knee

D. NICULESCU[1)], D. GRECU[1)], CARMEN NICULESCU[2)], I. E. PLEŞEA[3)], S. D. ENACHE[3)]

[1)]*Department of Orthopedic Surgery*
[2)]*Department of Pediatry*
[3)]*Department of Pathology*
Emergency County Hospital of Craiova
University of Medicine and Pharmacy of Craiova

Abstract

The authors present the results of optical microscopic studies of some lesions of cartilage and subchondral bone of the knee, the arthroscopy allowing this structure's biopsy during the endoscopic procedures. These histological criteria are very important estimation factors of long term results of these "repair" techniques, the microstructure showing the real biological status of these specific tissues.

***Keywords*:** arthroscopy, biopsy, cartilage, microstructure.

Introduction

Arthroscopy has become an extremely efficient way to diagnose and treat many affections of the knee with a quick recovery benefit for the patient.

Chondral and bone-chondral lesions of the knee – traumatic, degenerative or vascular – still represent a challenge for the modern medicine, since the late results of their endoscopic treatment are not always satisfactory and can lead to invalidating secondary arthritis of the knee articulation.

Material and methods

The microscopic study of the wounded and endoscope-"repaired" structure may provide long term evolutional prognosis criteria, arthroscopy proving its multi-potent quality as modern surgical method, allowing the precise, aimed collection of bioptic micro-fragments, without compromising the other unscathed structures of the knee.

The following surgical arthroscopy techniques have been studied and "bioptically" used:

- chondral broadening (in the partial cartilage lesions);
- sub-chondral bone micro-fracture (in the total cartilage lesions);
- bone-chondral metal fixation (in the dissect inflammation of the bones and cartilages).

Collected tissue fragments (articulation cartilage, sub-cartilage bone) have been sampled from a microscopically unscathed area or an area with minimal endoscope-visible changes, in order to verify whether there is a full concordance between this aspect and the microscope one, which in fact minutely reflects the biologic and microstructure status of the tissue at that moment, and which may have an evolutional prognosis role of the affection.

The histological study of the endoscope-resulted micro pieces has taken place in optical microscopy, HE staining.

Results

Anatomic and pathologic aspects in the "partial" chondral lesions

We have collected, from the arthroscopic intervention, chondral fragments from the 3rd degree, arthroscopical-treated through broadening focal point, from a number of 20 patients (10 cases under 45 years, 10 cases after 45 years), which have been examined at optic microscopy (Figures 1 and 2).

The microscope structure of the articulation cartilage collected from the young patients has a homogeneous aspect of the tissue matrix, without split spaces, with a relatively uniform distribution of the chondrocytes (Figure 1), proving chondral structure integrity at this age and a purely traumatic etiology of the lesion.

All cartilage samples collected from patients after 45 years have had an incipiently degenerative aspect, with split spaces in the matrix, a small number of chondrocytes and focal granular degeneracy (Figure 2), thus reflecting the importance of the degenerative factor in the generation of a cartilage lesion over this age limit.

Anatomic and pathologic aspects in "total" chondral lesions

The secondary arthroscopic intervention on a number of four patients, who have also needed the plasty of the crossed anterior ligament within 60–90 days, besides the bone micro-fracture treatment of the total chondral flaw, has given us the opportunity to collect bioptic micro-pieces from both the chondral regeneration tissue and the sub-chondral bone.

The purpose has been to establish the histological structure of the regenerated cartilage (Figure 3), as well as the extent to which this structure is close to that of the normal hyaline cartilage (Figure 1), but also to measure the reaction of the sub-chondral bone to its reparatory chondral tissue-generating micro-fracturing (Figure 4).

The microscopic aspect of the regeneration tissue collected from the micro-fracturing focal point was that of a hyalinoidal cartilage, an intermediate tissue between the hyaline cartilage and the fibro-cartilage (Figure 3). In comparison with the hyaline chondral tissue (Figure 1), there are a larger number of chondrocyte cells, with a higher percentage of young fibroblastic cells.

The surrounding matrix is mainly formed of thick fascicles of collagen fibrils with anarchic distribution, in contrast with the regulated orientation of the fibers in the hyaline cartilage.

The important fact is that there have been no fiber connections between this regeneration tissue and the hyaline, normal, surrounding tissue; on the contrary, incipient degenerative processes have been noticed to early appear at the level of this interface, which microscopically proves the fact that the critical area of chondral regeneration is the marginal, peripheral one.

The structure reaction of the micro-fractured sub-cartilage bone is characterized by the recovery of the normal bone tissue, which also has some islands of fiber tissue, respectively hyalinoid cartilage tissue, together with blood vessels, which microscopically proves the processes of local cellular metaplasy that generate the reparatory cartilage tissue.

The bone-cartilage junction is microscopically highlighted, with continuous fiber structures and an optimal calcification of the profound, resistance layer of the regeneration cartilage (Figures 3 and 4).

Microscopic aspects in the bone-chondral metal fixation

Late secondary arthroscopy has allowed the collection, in two cases of König disease of the 3rd stage, of some micro-cups from the chondral tissue, as well as from the sub-chondral bone, from the level of the screw trajectory, after its suppression.

The microscopic aspect of the hyaline cartilage from the bone-necrosis focal point level, clinically, radiologically and arthroscopically cured, is very suggestive for the "vascular crisis" of the subjacent bone and, subsequently, of the former. Thus, there are many young cells of large dimensions, with chondroblast aspect, thus with a high regeneration potential, crowded in the immediate surrounding of the bone tunnel of the fixation screw, as well as at the periphery of the chondral area (Figure 5).

The hyaline cartilage does not have signs of degeneracy, the matrix being homogeneous, without split spaces and with a uniform distribution of the chondrocytes, with an unscathed cartilage – sub-chondral bone junction (Figure 6), which microscopically proves the integration of the bone-chondral fragment following the appropriate therapeutic intervention (metal fixation and temporary regime of protection and articulation ease).

The microscopic structure of the sub-chondral bone, after the healing of the ischemic lesion is normal, the markers of the initial vascular suffering being the abundance of the neo-formation blood vessels, as well as the presence of some islands of neo-formation hyalinoid cartilage, elements which certify the increased reparatory biological activity from the level of the bone tissue, caused by the initial vascular crisis.

Discussions

Regarding the "partial" chondral lesions, the differences in the post-operation evolution of various age groups might have an explanation in the different state of the articulation cartilage, meaning biologically normal at those under 45 years and with incipient degenerative processes at those after 45 years [1].

These histological differences might explain the extremely large incidence of partial and clinical oligo-symptomatic chondral lesions at the second age category, as well as the more difficult and long-lasting post-operation recovery of these patients, with period of clinical relapse [2, 3].

The microscope aspects in "total" chondral lesions show that the micro-fracturing method is efficient in triggering a local vascular crisis and initiating the reparatory process starting from the sub-chondral bone level, which may even "produce" a hyalinoid cartilage [4, 5, 8, 10].

However, due to the critical area – a lack of fusion between the regenerated neo-cartilage and the surrounding normal hyaline one – a long-lasting post-operation recovery is still needed, with the prohibition to burden the knee for at least 90 days, and then a permanent mechanical protection of this articulation [3, 5, 7, 10].

That is why, at the Annual Meeting of the American Academy of Orthopaedic Surgeons, San Francisco, February 12–15, 1997, Professor Mow concluded, "If we do not have strong knitting at the juncture, that tissue is doomed by physical principles to fail. It may be 3 years, it may be 5 years, but I can predict it as simply as Newton's laws" [6].

The histological results we have noticed in these researched cases of sub-chondral bone microfracturing are absolutely similar to those communicated by authors such as Brittberg (1994), Mankin (1996), Buckwalter (1997), Bobic (1999), Steadman JR (1999), Imhoff (1999), Peterson (2000), Minas (2000), Lindahl (2001), Angermann (2002).

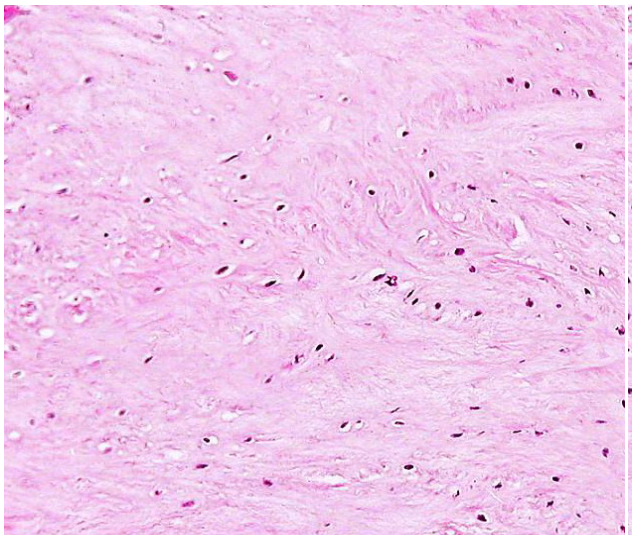

Figure 1 – ***Microscopic aspect in "partial" chondral lesion, to a 25 years old patient (HE staining, oc. ×10, ob. ×10)***

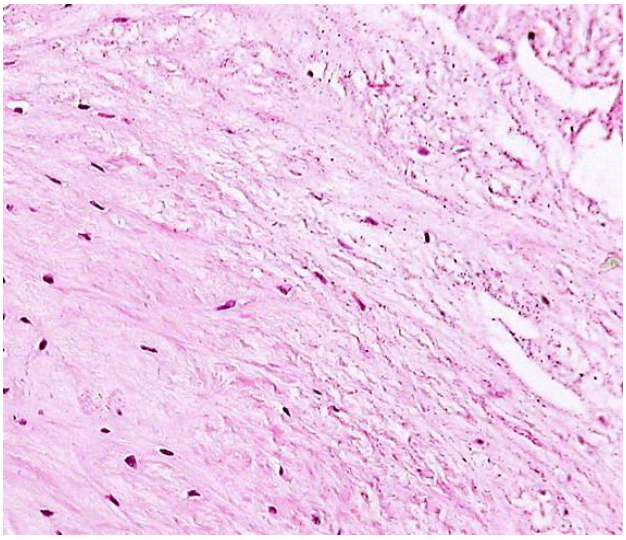

Figure 2 – ***Microscopic aspect in a 3rd degree chondral lesion, to a 55 years old patient (HE staining, oc. ×10, ob. ×10)***

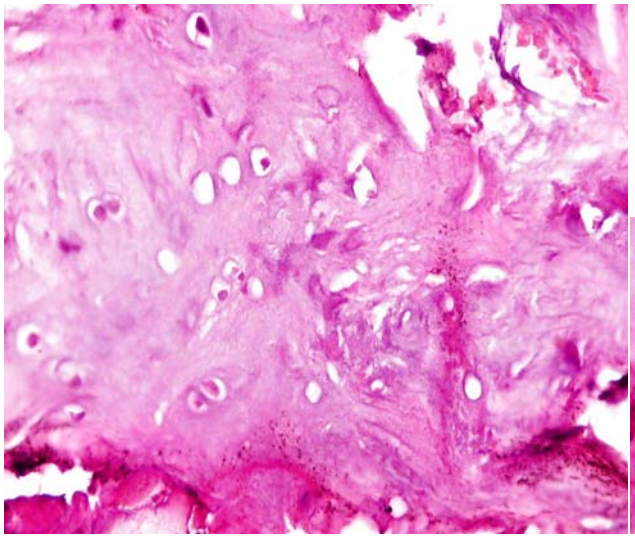

Figure 3 – ***Microscopic aspect of the regenerated cartilage (HE staining, oc. ×10, ob. ×40)***

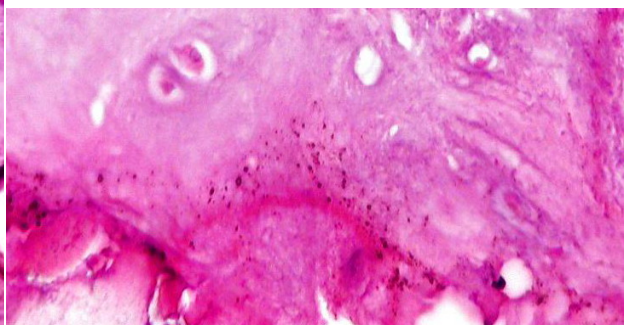

Figure 4 – ***Microscopic aspect of sub-chondral bone (HE staining, oc. ×10, ob. ×40)***

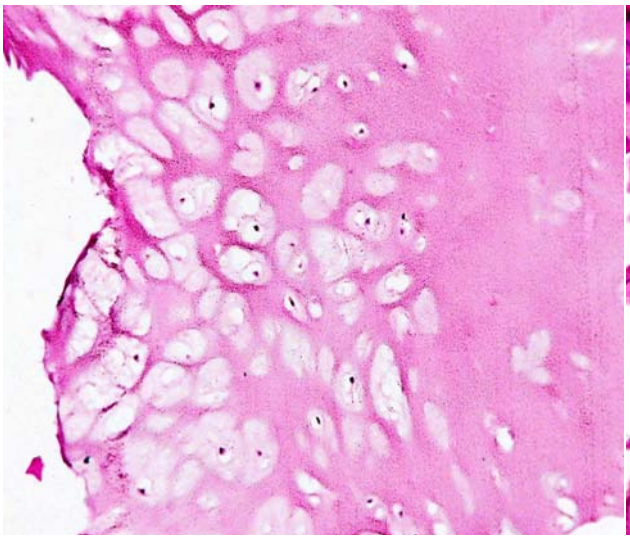

Figure 5 – ***Microscopic aspect of cartilage after the chondral bone fragment's integration (HE staining, oc. ×10, ob. ×40)***

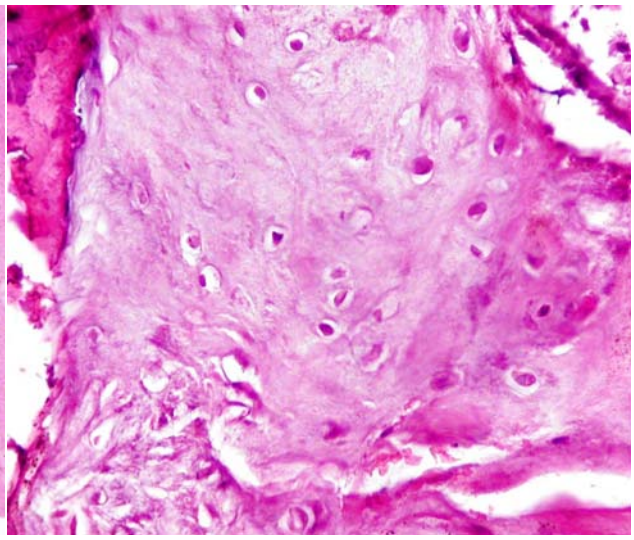

Figure 6 – ***Microscopic aspect of sub-chondral bone and upper cartilage after the chondral bone fragment's integration (HE staining, oc. ×10, ob. ×40)***

In the König disease, this extremely simple way of bioptic collection, at the suppression of the temporary fixation screw, may highlight the degree of biological healing of lesions, cartilage and bone too, thus correctly establishing the subsequent regime of mechanical effort of the knee and providing the young patient with an actual late prognosis [9].

Conclusions

Although the main purposes of the knee arthroscopy are those of diagnosis and, mostly, of therapy, this method successfully provides the histological study of the intra-articulation lesions, such as the lesions of the articulation cartilage and of the sub-chondral bone, which are important both from the perspective of their high incidence, but also from the perspective of their severe arthrosic evolutional process.

The investigation results show that the unscathed macroscopic aspect and the microstructure aspect are not always in concordance, since the cellular biologic degenerative process arises much earlier that the debut of the alarm clinical signs and depends both on the age of the patient, and on the previous aggression of that tissue.

Furthermore, the success of some reparatory endoscopic interventions may be correctly assessed based on the microstructure aspect, which will highlight both the areas of tissue repair or regeneration, its quality, and the areas with "reparatory problems", where the macroscopic success is only apparent.

The establishment of this biologic tissue state is possible due to an endoscopic intervention on the knee that allows the bioptic sampling, and may have an essential role in the early and late post-operation therapeutic conduct, as well as in the assessment of a long-term functional prognosis of the operated knee.

References

[1] ANGERMANN P., HARAGER K., TOBIN L. L., *Arthroscopic chondrectomy as a treatment of cartilage lesions,* Knee Surg Sports Traumatol Arthrosc, 2002, 10(1):6–9.

[2] BUCKWALTER J. A., MANKIN H. J., *Articular cartilage I. Tissue design and chondrocyte–matrix interactions,* J Bone Joint Surg Am, 1997, 79A(4):600–611.

[3] BUCKWALTER J. A., MANKIN H. J., *Articular cartilage II. Degeneration and osteoarthrosis, repair, regeneration and transplantation*, J Bone Joint Surg Am, 1997, 79A(4):612–632.

[4] LINDAHL A., BRITTBERG M., PETERSON L., *Health economic benefits following autologous chondrocyte transplantation for patients with focal chondral lesions of the knee,* Knee Surg Sports Traumatol Arthrosc, 2001, 9(6):358–363.

[5] MINAS T., CHIU R., *Autologous chondrocyte implantation,* Am J Knee Surg, 2000, 13(1):41–50.

[6] MOW V. C., *Articular cartilage regeneration: Chondrocyte transplantation and other technologies (symposium)*, Annual Meeting of the American Academy of Orthopaedic Surgeons, San Francisco, February 12–15, 1997.

[7] PETERSON L., LINDAHL A., BRITTBERG M., NILSSON A., *Durability of autologous chondrocyte transplantation of the knee*, Program and abstracts of the 67th annual meeting of the American Academy of Orthopaedic Surgeons, March 15–19, 2000, Orlando, Florida, paper no. 125.

[8] RADIN E. L., ROSE R. M., *Role of subchondral bone in the initiation and progression of cartilage damage*, Clin Orthop Relat Res, 1986, 213:34–40.

[9] SHARMA C., BATTISTONE M., ANDERSON A. F., RICHARDS D. B., PAGNANI M. J., HOVIS W. D., *Avascular necrosis*, Medicine Journal, 2002, 3(2):319–324.

[10] STEADMAN J. R., RODKEY W. G., BRIGGS K. K., RODRIGO J. J., *The microfracture technique in the management of complete cartilage defects in the knee joint*, Orthopade, 1999, 28(1):26–32.

Corresponding author

Dragoş Niculescu, MD, Department of Orthopedic Surgery, University of Medicine and Pharmacy of Craiova, Emergency County Hospital, 1 Tabaci Street, 200 642 Craiova, Romania; Phone +40251–502 428, +40251–502 362, E-mail: niculescudragos@yahoo.com

Received: July 13th, 2007

Accepted: October 10th, 2007