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Patellar tendon + LAD in ACL reconstruction

(experimental study in goats: histological evaluation, preliminary report)

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Ön çapraz bağ rekonstrüksiyonunda patellar tendon + LAD
(Keçilerde yapılmış deneysel çalışma:histolojik değerlendirme ve ön rapor)

Keçilerde pateller tendon otogrefti ve ligaman ogmentasyon cihazı (LAD) kullanılarak ÖÇB rekonstrüksiyonu yapıldıktan sonra implant ve çevresindeki kemikten alınan dokuların histoloji incelemesi yapılmıştır. İmplantın biolojik kısmı ve kemik tüneli arasındaki dokunun morfolojisi fizyolojik kemik-ligaman geçişine benziyordu. Buna karşın LAD'nin çevresinde ve onu kemik tünelinden ayıran bölümde fibroz doku artışı saptanmıştır. Sentetik cihaz ve patellar tendon arasındaki dokuda aynı tip fibroz doku artışı tesbit edilmiştir.

Anahtar kelimeler: *ÖÇB yaralanmaları, ligaman ogmentasyon cihazı (LAD)*

Following reconstruction of the anterior cruciate ligament in goats using the patellar tendon allografts plus ligament augmentation devices, histological examination of the junction between the implant and the surrounding bone was carried out. The junction that formed between the biological pportion of the implant and the bone tunnel was morphologically identical to physiological bone-ligament juctions. In contrast, fibrous tissue was found surrounding the LAD and separating it from the tunnel walls around it. The junction that formed between the synthetic device and the pateller tendon was also composed of the same type of fibrous tissue.

Key words: *Anterior cruciate ligament ınjuries, ligament augmentation device (LAD)*

A great deal of attention has recently been devoted to the study of structural and ultrastructural modifications that occur in both biological and synthetic materials used to reconstruct the anterior cruciate ligament (ACL). Most studies computed so far have concentrated on the intra-articular portion of these implants. Less in currently known about the changes that occur in the extra-articular tract. The junction that forms between the ligament implant and the bone to which it is attached is, however, one of the most crucial areas of the reconstruction.If fixation is poor, the new ligament will not be able to endure the considerable stress to which it is subjected during sports activities or even those of daily life. Studies conducted by Cooper (5) and Benjamin (4) have shown that the physiological bone-ligament junction is composed of four layers:

1. Ligament,
2. Fibro-cartilage,
3. Mineralized fibro-cartilage and,
4. Bone.

The biomechanical properties of this type of junction provide optimal levels of both stability and elasticity. Because of its particular structure, theligament junction is, in fact, able to withstand there to four time the strain that can be supported by the central portion of the ligament. The present study was conducted to compare the histological features of the physiological bone-ligament junction with the one that forms when the ACL is reconstructed using the patellar tendon together with a ligament-augmentation device (LAD).

Materials and methods

Ten Tibetan dwarf goats with a mean weight of 25 kg were subjected to reconstruction of the ACL in one of the posterior limbs using patellar tendon allografts together with ligament-augmentation devices consisting of braided bundles of polypropylene. The contralateral limb was used as a control. The animals were sacrificed at post-operative intervals that ranged from 28 days to 12 months.

Surgical technique:

The goats were anesthesized with diazepam, ketamine hydrochloride and a combination of nitrogen protoxide + halothane. Under aseptic condition, a longitudinal incision was made along the median line from the patella to the tibial tuberosity. The central third of the patellar tendon without bone at the extremities was removed. The adipose pad was sectioned and shifted laterally to expose the ACL which was re-

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moved complete with its femoral and tibial insertions. The patellar tendon was attached to the LAD by means of nonabsorbable, interrupted sutures. Isometric points were identified in both the femur and tibia and bone tunnels were drilled in each using 5 mm bits. After implantation of the new ligament, the wounds were sutured layer by layer. The animals were not immobilized in any way after surgery.

Histological technique:

The animals were sacrificed and the knees removed and fixed in glutaraldehyde and 4 % buffered formalin. The specimens were decalcified in EDTA and embedded in methacrylate or paraffin.Sections (3-4 microns for methacrylate-embedded specimens; 7 microns for those in parafin) were cut perdendicular to the tunnel axes and stained with hematoxylin-eosin, toluidine blue, Mallory's triple, and Masson's trichrome stain for light microscopy studies.

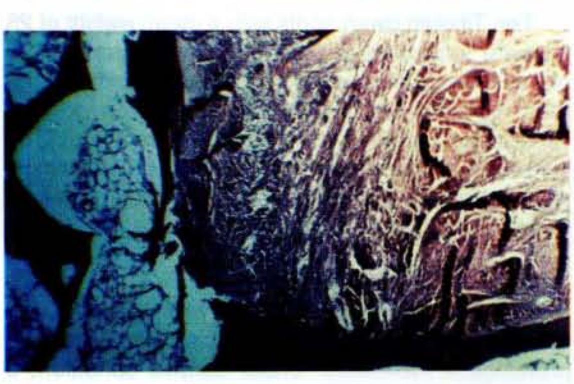
Results

Macroscopic findings:

All of the specimens examined presented more or less marked fibrous thickening of the articular capsule even though all but one of the animals had shown full joint mobility. The implanted ligament could be easily visualized within the joint. Edema of the biological portion of the implant was found only in the animal sacrificed on the 28th post-operative day.

Histological findings:

The specimen from the goat sacrificed on day 28 showed edeme of the implanted patellar tendon and collagen fiber disorder which were characteristic (1, 2) of this phase (Figure I).



Figur I: - 28 days. the patellar tendon allograft within the bone tunnel shows edema and fiber disorders. A thin fibrocartilage layer can be seen at the bone-ligament interface

The LAD could be seen clearly: the polypropylene bundles were intact and individually surronded by thin sheaths of fibrous tissue. Two and there months after surgery, the fibrous sheaths surrounding the single, bundles, as well as that enveloping the LAD in toto, had increased in thicknees. There were no signs of either edema or necrosis in the biological portion of the implant. The histologicals findings six months after surgery had not changed substantially. The LAD was still surrounded by fibrous tissue which appeared to be well vascularized and infiltrated by monocytes; no foreign body cells were present (Figur II).

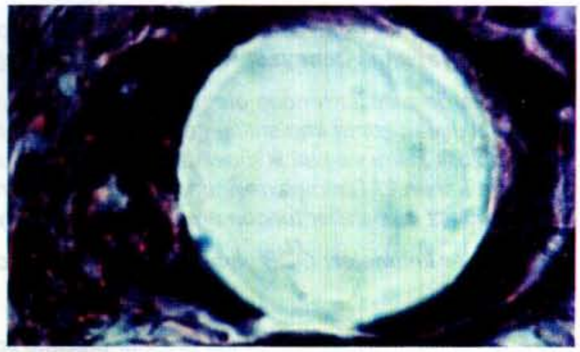


Figure II: - 2 months the tissue surrounding the LAD is rich i cells;

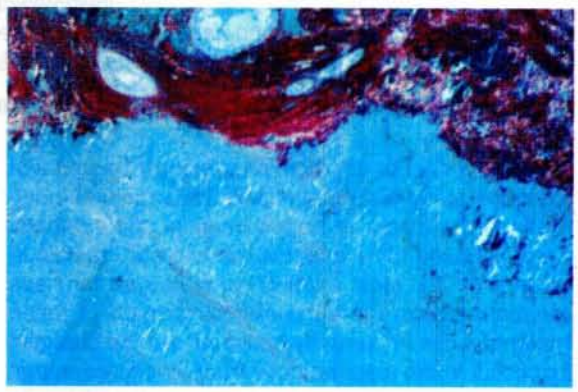


Figure III: - 3 months P T insertion resemble physiologic junction, but is thinner

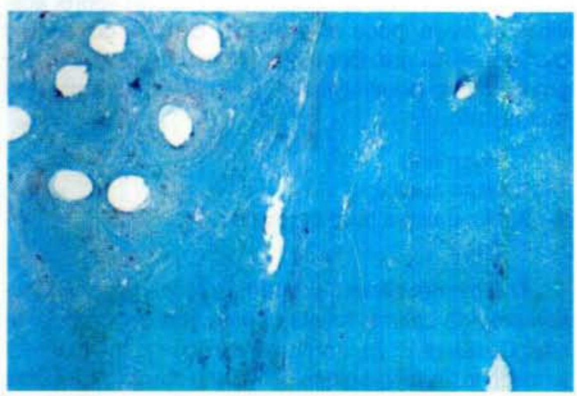


Figure IV: -6 months the LAD, clearly seen on the left, is separated from patellar tendon, on the right, only by fibrous tissue (in the middle).

A neojunctional structure could be observed between the implanted tendon and bone (Figure III).

The implanted tendon was separated from the synthetic augmentation device by fibrous tissue (Figure IV).

The LAD was still separated from the bone tunnel walls and the tendon allograft by fibrous tissue 12 months after surgery (Figure V).

Figure V: - 12 months the fibrous tissue has thickened and there is no fibrocartilage at the bone-ligament interface

Within the device there were neither aligned collagen bundles nor trabecular growth. However, Shapney fibers seemed to form a direct connection between the tendon and the surrounding bone wall (Figure VI).

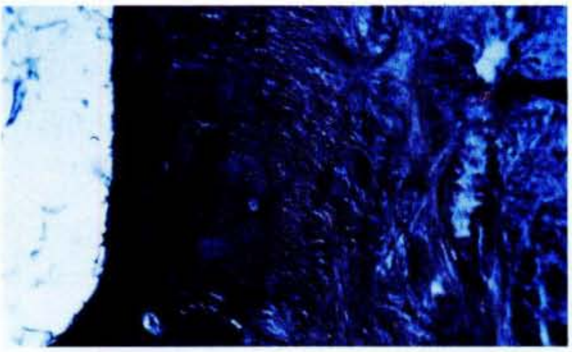


Figure VI: - 12 months the patellar tendon allograft has no more signs of degeneration and its insertion on the tunnel wall resemble a physiologic juntion

The four zones typical of the physiological junction could now be identified: ligament, fibro-cartilage, mineralized fibrocartilage and bone.

Discussion

We performed ACL reconstructions using patellar tendons with LAD in ten Tibetan goats to identify the characterisics of the interface between the neoligament and the bone tunnel. After an initial phase of degeneration characterized by edema, necrosis and collagen fiber disorder (Figure I), the patellar tendon gradually improved and was found to be well inserted within the bone tunnels without any of the signs of injury previously observed (1, 2). During the observation period, the LAD gradually became enveloped in a sheath of intensely cellular fibrous tissue which has been already described (8, 11) (Figures 4,5). This sheath formed the attachment between the synthetic device and the biological structures (patellar tendon allograft and bone tunnel walls). We were unable to find any bundles of collagen fibers within this sheath even in the specimen from the goat sacrificed one year after surgery. In constrast to findings in other types of synthetic ligaments (9), there was no observable trabecular bone growth within the LAD (3).

Conclusion

The growth of bone trabeculae has been described within ligament prostheses made of Dacron or Goretex (6), but our findings confirm those of other authors (1, 7, 9, 12), who affirm that trabecular growth does not occur within the lad. Even the contact between the device and the patellar tendon allografts was mediate by fibrous tissue. Van Kampen (13) has pointed out that the presence of a fibrous interface between bone and neoligament gives this type of transplant an elastic fixation that can not be achieved if the neoligament is attached to the tunnel walls by trabecular bone growth. While this type of junction does indeed represent an advantage over other synthetic ligaments, it cannot, in our opinion, be compared to the one that forms between a biological transplant and the surrounding bone. The biomechanical characteristics of this latter type of insertion are undoubtedly superior in that it is morphologically similar to the physiological junction. Compared with attachments formed by either bone or fibrous tissue alone, the junction that forms between the patellar tendon and the surrounding bone wall is not only solid but also more elastic. The fibro-cartilage that forms at the bone-ligament interface is able to act as a "stretching brake". This would provide the new junction with the same elasticity found in the physiological junction, as Noyes and Butler have demonstrated (10). An analysis of our findings indicates that the LAD should always be tubulized also in the extra-articular zone so that contact with the tunnel walls is always mediated by biological rather than synthetic material.

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