KNEE LIGAMENTOPLASTY AND OSTEOARTHRITIS: CARTILAGE MECHANICAL PROPERTIES AND BONE MICROARCHITECTURE

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Introduction
Osteoarthritis is a degenerative joint disease affecting all tissues of the articulation: cartilage, bone, meniscus, etc. Several studies reported the appearance of osteophytes [1, 2], alterations of articular cartilage [1, 2] and of subchondral bone in animal models [3]. In case of accidental cruciate ligament rupture in humans, a ligamentoplasty is often considered to restore joint stability. The effects of such a surgery on osteoarthritis development are unknown. In the present study, we used a rabbit model to evaluate the effects of an anterior cruciate ligament transection (ACLT), directly followed by a ligamentoplasty, on the appearance of osteoarthritis symptoms.

Methods
For this study, 2 groups of six 6-month New-Zealand white rabbits were used. A control group was left without any surgery. A group underwent an ACLT directly followed by a ligamentoplasty and samples were collected 6 weeks later. Tibias and femurs were dissected and macroscopic lesions were graded from 0 (no lesion) to 3 (severe lesions). Microtomography analyses were run for each sample using a Nanotom (GE, USA) and the following acquisition parameters: 90kV, 120µA, 750ms, resolution of 13.5µm. Microarchitectural parameters, such as subchondral plate thickness, BV/TV and trabecular thickness of subchondral trabecular bone, were identified using the software CTan (Brücker microCT, Belgium). A Nano Indenter G200 (ScienTec, France) was then used to run microindentation tests on cartilage surface with a spherical glass probe. The loading phase was made at 5µm/s to a depth of 40µm, a holding phase of 400s was applied and the unloading phase was run at 0.05µm/s. Load and displacement data enable to determine some elastic and viscoelastic properties of the cartilage.

Results
Macroscopically, femurs with ligamentoplasty presented osteoarthritis-like lesions: cartilage alterations, osteophytes, etc (see Figure 1). These osteophytes were also visible on 3D microtomography reconstruction suggesting that they are mineralized (see Figure 2). The ligamentoplasty tunnel made during surgery was still present after 6 weeks (see Figure 3). Mechanical properties of cartilage were also affected especially on the medial condyle with a significant decrease of reduced elastic modulus.

Discussion
In this work, we have developed methods to characterize microarchitectural modifications of subchondral bone in case of ligamentoplasty along with changes in articular cartilage mechanical properties. Results evidenced macroscopic anatomical changes, and a significant decrease of cartilage elastic modulus. Such symptoms are similar to those of osteoarthritis.

References

Figure 1: Left (contralateral, a) and right (operated, b) femur extremities of a rabbit that underwent a ligamentoplasty. The right femur is grade 3 (severe) because of cartilage lesions and numerous osteophytes.

Figure 2: 3D reconstruction after microtomography of a left contralateral (a) and right operated (b) femur extremity of a rabbit that underwent a ligamentoplasty.

Figure 3: Cross-section of the right femur extremity showing the ligamentoplasty tunnel.

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