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Bio-mechanical Properties of a New MPFL Reconstruction Technique Using Quadriceps Tendon in Comparison to the Intact MPFL. A Human Cadaveric Study

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Summary:
In this biomechanical human cadaver study (13 knees) structural properties (stiffness, yield load and maximum load) of a new MPFL reconstruction technique using a strip of quadriceps tendon with remaining attachment at the proximal patellar pole have been evaluated and compared to the intact MPFL. There was no significant difference between the reconstructed and intact MPFL ($p>0.05$).

Abstract:
Introduction:
Reconstruction of the medial patellofemoral ligament (MPFL) for the treatment of patella instability has achieved increased attention over the last few years. Several surgical techniques have been described. Most of them are using hamstring tendons as the graft of choice. Despite excellent clinical outcomes and small re-dislocation rates, some complications have been experienced such as implant breakage, patella fractures through bone tunnels, loss of knee flexion and patellofemoral OA. Currently, there is only very limited information available on the biomechanical properties of the original MPFL. From the results of a previous study evaluating the biomechanical properties of various hamstring reconstruction techniques we speculated that the stiffness of these constructs might be much higher than that the original MPFL. There are few reports on MPFL reconstruction using a strip of quadriceps tendon without anchors or bone tunnels in the patella. We hypothesized that a quadriceps tendon reconstruction technique more closely resembles the structural properties of an intact MPFL.
The aim of this study was (1) to analyze the structural properties of the original MPFL and (2) to compare it to a new MPFL reconstruction technique using a strip of quadriceps tendon with remaining attachment at the proximal patellar pole.

Methods:
In 13 fresh frozen human cadaver knees the MPFLs have been dissected protecting its patellar insertion. The patellar has then been fixed in a custom made device with a Steinman pin and a k-wire (the proximal and distal patellar pole in a horizontal line). The MPFL has been fixed with the femoral insertion part in a tendon clamp and positioned in an unaxial testing machine (Zwick Roell Z005).

(1) In the first part of the study the MPFL has been loaded to failure after preconditioning with 10 cycles between 5 and 20 N. During load to failure tests the following parameters have been evaluated: Stiffness, Yield load and Maximum load to failure.
(2) In the second part of the study MPFL reconstruction with the middle third of the quadriceps tendon has been performed. A 10mm wide, 3mm thick and 9 cm long strip of quadriceps tendon was prepared. The tendon strip was

left attached at the patella and diverged 90° underneath the prepatellar tissue. At the medial boarder of the patella the tendon strip was fixed with two No2 nonresorbable sutures. The free part of the tendon strip has been fixed in the clamp and the patella has been positioned in the fixation device identically to the intact MPFL testing. The constructs have been preconditioned with 10 cycles between 5 and 20 N. Following preconditioning the constructs were cyclically loaded 1000 times between 5 and 50 N. During cyclic testing the maximum elongation has been measured. After cyclic testing the constructs have been loaded to failure. The following parameters have been investigated during the load to failure tests: Maximum elongation after 1000 cycles, Stiffness, Yield load and Maximum load to failure.

For statistical analysis we used a Wilcoxon Rank test. The significance was set at $p<0.05$.

Results:
(1) During the load to failure tests of the original MPFL the following results have been measured: Stiffness: 29.38 N/mm (+9.75), Yield load: 167.83 N (+80.01) and Maximum load to failure: 190.66 N (+ 82.8).
(2) Maximum elongation after 1000 cycles was 2.09 mm (+0.75). In the load to failure testing of the quadriceps tendon reconstruction group we obtained the following results: Stiffness: 33.6 N/mm (+.6.78), Yield load: 147.08 N (+65.09) and Maximum load to failure: 204.96 N (+77.79).

There were no significant differences in all the tested parameters between the intact MPFL and the reconstructed group using quadriceps tendon (Stiffness: $p=0.15$, Yield load: $p=0.24$ and Maximum load to failure $p=0.69$).

Discussion:
The results of the present study support our initial hypothesis that the MPFL reconstruction technique using a strip of quadriceps tendon demonstrated comparable biomechanical results to the intact MPFL.
To our knowledge the present study is also the first to investigate the stiffness of the original MPFL.
In a biomechanical study by Lenschow et al. the stiffness of various MPFL reconstruction techniques using hamstrings was found to be between 87 and 97 N/mm. This is nearly three times the amount of the intact MPFL. This unnatural increased stiffness could possibly result in a higher patellofemoral pressure during knee flexion.
Therefore MPFL reconstruction using a strip of quadriceps tendon seems to be a promising alternative to widely used hamstring reconstruction techniques. Complications of hamstring reconstruction techniques like patellar fracture or irritations at the patellar fixation site as well as the risk for loss of motion and patellofemural OA (caused by increased patellofemoral pressure) may potentially be minimized or prevented.

Clinical relevance:
The tested quadriceps reconstruction technique of the MPFL shows sufficient primary stability with comparable biomechanical parameters to the intact MPFL. Therefore this technique seems to be an interesting alternative to the common reconstruction techniques using hamstring grafts with potential to minimize complications.

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