THE EVALUATION OF THE PULL OUT FORCE BETWEEN THE OSTEOCHONDRAL PLUG AND THE RECEIVING TUNNEL IN AUTOLOGOUS OSTEOCHONDRAL TRANSPLANTATION

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Keywords: *autologous osteochondral transplantation, pull out, receiving tunnel, osteochondral plug*

Abstract: *The Osteochondral Autologous Transplantation is a technique wich implant in the area of a chondral defect osteochondral plugs harvested from a donor area for filling chondral defects. The stability of the plugs influence the outcome and the rehabilitation. The purpose of this study is to determine the pull out force between the plug and the receiving tunnel. We have performed 4 tunnels in a beef femoral condyle in each of them we have grafted a plug anchored by a metal wire. The femur was positioned at the Instron 5587 Testing Machine, then we have applied traction for each of the cilinders separately in ax until they were pulled out. The results shows that the plug has a good pull out resistance. The pull out force is increasing quickly until it's maximum then it's decreasing slowly at 100 N. The plug is moving inside the tunnel 35-40% of it's lenght until it reach the maximum pull out force.*

Cuvinte cheie: *transplant osteocondral autolog, smulgere, tunel primitor, cilindru osteocondral*

Rezumat: *Transplantul osteocondral autolog este o tehnică prin care se recoltează cilindri osteocondrali dintr-o zonă donoare şi se implantează în zona defectului cartilaginos, ceea ce realizează repararea defectului. Stabilitatea cilindrilor transplantaţi influenţează recuperarea şi rezultatul final. Scopul acestui studiu este de a determina forţa de smulgere dintre cilindrul osteocondral şi tunelul primitor. Pentru aceasta am realizat 4 tuneluri la nivelul condililor unui femur de vită în care am transplantat câte un cilindru osteocondral ancorat de tije metalice în ax. Femurul astfel prelucrat a fost poziţionat în Maşina de încercare Instron 5587, apoi s-a realizat tracţiunea în ax pentru fiecare cilindru separat până la smulgerea lor din tunel. Rezultatele obţinute arată că cilindrul transplantat prezintă o bună rezistenţă la smulgere. Forţa de smulgere creşte relativ rapid până la valoarea maximă, după care scade lin până la 100 N. Cilindrul se deplasează în tunel 35-40% din lungimea sa până se atinge forţa maximă de smulgere.*

INTRODUCTION

The articular cartilage has a limited spontaneous regeneration capability. When it occur, the regeneration of a chondral lesion is partial and the repaired tissue is fibrocartilage with inferior mechanical properties compared to the hyaline cartilage. The Osteochondral Autologous Transplantation is a technique wich implant in the area of a chondral defect osteochondral plugs harvested from a donor area for filling chondral defects, achieving a reparation with hyalin cartilage [1, 2]. The stability of the plugs influence the outcome and the rehabilitation [3].

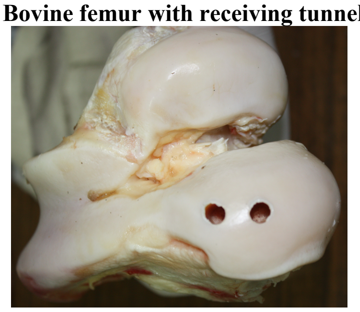
PURPOSE

The purpose of this study is to determine the pull out force between the plug and the receiving tunnel, as being a characteristic of the bone tissue with role in the primary stability of the transplant [4].

TERIAL AND METHODS

To acheve this purpose we have prepared a fresh bovine femur. After deperiosting end removal of the ligamentous tissue we have performed 4 tunnels 20 mm deep in the femoral condyles (fig. 1.). The positioning of the tunnels was performed for allowing after the fixation of the femur at the inferior device of the experimental stand on the Instron 5587 Testing Machine the positioning of the tunnels in the vertical axis. After performing an osteochondral transplant the plug was submitted to a traction force in order to determine the pullout force of the cylinder from the receiving tunnel. So, we were able to perform the traction of the transplanted osteochondral plugs along their longitudinal axis. The traction was performed with forces constant increasing from 0 N up to the pullout of the plug.

Figure no. 1. Bovine femur with receiving tunnels



Then, we have grafted 4 plugs 8 mm diameter and 15 mm long from the femoral trochlea of the same femur. The exact lenght of this plugs was measured for the calculation of the pullout forces. Each cylinder was then drilled in it's axis and thru this hole was introduced a metal wire with a ring fixed at the base of the osteochondral plug (fig. 2.). The lenght of each plug was aproximately 15 mm, which left a space between th ebase of the plug and the base of the receiving tunnel were was positioned the ring fixed on the traction metal wire.

After this, we have performed the transplantation of a

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plug in one of the receiving tunnels, then the femur was positioned at the inferior device of the experimental stand on the Instron 5587 Testing Machine and the wire was fixed on the superior mobile sleeper of the machine (fig. 3.).

Figure no. 1. Osteochondral plugs, drilled, two of them with traction wires

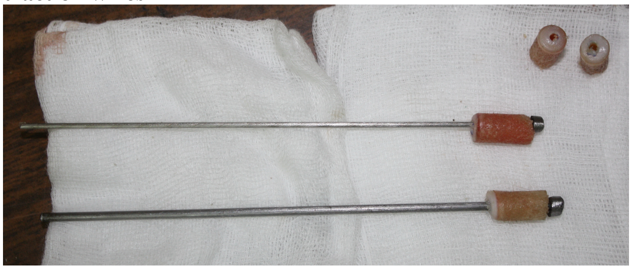
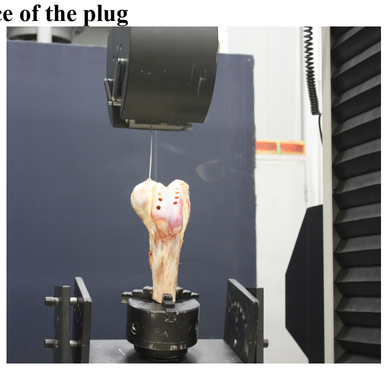


Figure no. 3. Bovine femur positioned on the Instron 5587 Machine during traction testing in order to determine the pullout force of the plug



This test was repeated 4 times for the corection of the experimental method. Each test was performed with a new plug transplanted in a different receiving tunnel. Th eresults of these traction tests are presented in table 1.

As mentioned before, the lenght of each plug was acurately measured, the area held of the plug and receiving tunnel contact surface was calculated with the relation:

$$S_{Desf} = 2\Pi R_{Cil} * L_{Cil}$$

And the parameters of the loading and displacement forces of the plugs were obtained from data received from the testing machine soft.

Table no. 1. Results of the osteochondral plugs traction tests

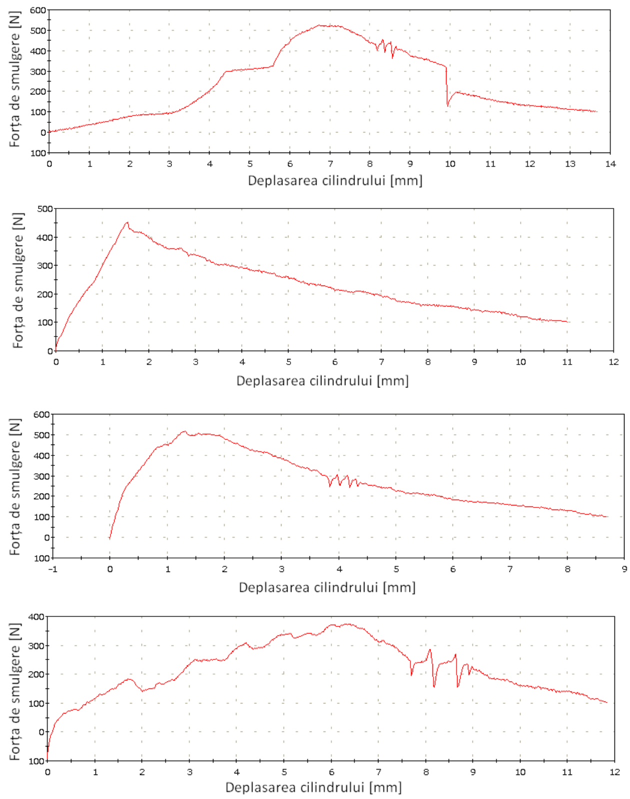
Number cylinder	Lenght cylinder L_{cil} [mm]	Area held of the contact surface [mm^2]	Maximum load [N]	Elongation at maximum load [mm]	Energy at maximum load [J]
1	15,84	398,10308	527,05826	6,71670	1,28071
2	16,67	418,96328	451,91834	1,54995	0,37541
3	15,57	391,31723	519,39277	1,31648	0,45559
4	16,65	418,46062	102,24636	11,83428	2,58702

REZULTS AND DISCUSSIONS

Figures 4. a, b, c, d, presents, for each of the four tested cylinders, the variation of the pullout force depending of it's displacement in the receiving tunnel during the traction testing.

The experimental results shows that the maximum pull out force of the plugs is around 500 N (the average value is 474,15 N), which shows that the transplanted plug has a good pull out resistance.

Figure no. 4. The variation of the pullout force of th eosteochondral plug depending of it's displacement in the receiving tunnel during the traction testing: (a) cylinder nr. 1, (b) cylinder nr. 2, (c)cylinder nr. 3, (d)cylinder nr. 4



There can be observed a good statistical distribution of the the experimental results. Regarding the evolution of the pullout force during the experiment, is increasing quickly until it's maximum then it's decreasing slowly at 100 N, when the test was stopped, considering the plug pulled out from the tunnel.

Regarding the displacement of the osteochondral plug inside the receiving tunnel, the plug is moving inside the tunnel 5-6 mm (35-40%) of it's lenght until it reach the maximum pull out force, at the final of the test being at approximately 14 mm (80-90%) outside the femur.

One can see also that on the descending slope of the pullout force vs. cylinder displacement curve there are some small variations of the pullout force, due probably to the fact that the holding is not constant on all the exterior surface of the plug because both the plug and the receiving tunnel are not geometrically perfect. This fact is not influencing significant the pullout force, because all these inperfections are producing effects after the maximum pullout force was reached, the point where we can consider that the assemblie plug-receiving tunnel start loosing it's efficiency.

CONCLUSIONS

The osteochondral plug has a good pull out resistance. The pullout force during the experiment is increasing quickly until it's maximum then it's decreasing slowly at 100 N. The osteochondral plug is moving inside the tunnel 5-6 mm (35-40%) of it's lenght until it reach the maximum pull out force. The holding is not constant on all the exterior surface of the plug because both the plug and the receiving tunnel are not geometrically perfect. This fact is not influencing significant the pullout force.

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