Delay of Cartilage Degeneration of Polyurethane Meniscal Substitute Alone or Enhanced with Autologous Mesenchymal Stem Cells Evaluated with T2-mapping at 24 Follow-up Months

Anell Olivos-Meza
Ana Bravo
Socorro Cortes
Pedro Rojas
Saúl Renan
Jonatan Hernandez-León
Francisco Perez-Jimenez
Julio Granados
Clemente Ibarra

National Rehabilitation Institute
Mexico City, MEXICO
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Purpose

- Evaluate the protective effect in the adjacent cartilage of polyurethane meniscal substitute alone or enhanced with autologous mesenchymal stem cells with T2-mapping at 24 follow-up months.
Methods

- Seventeen patients with a history of partial meniscectomy underwent to polyurethane meniscal substitute (Actifit®) alone (MS-A) or enhanced with mobilized mesenchymal stem cells (MS-MSC).

- In the MS-MSC, three doses of 300mcg of Granulocyte Colony Stimulating Factor (G-CSF) were injected, at day 4 a buffy coat with mobilized MSC was obtained in peripheral blood, those cells were seeded in the meniscal substitute.

- The meniscal substitute was implanted by arthroscopy and concomitant lesions were treated.

- T2 mapping and clinical knee scores were applied.
Peripheral blood sample with mobilized mesenchymal stem cells after granulocyte colony stimulating factor application. A) Blood unit was separated from the leukocyte fraction “buffy coat”. B) Mononuclear cells were isolated from the buffy coat in an automated equipment (biosafe). C) Staining of mononuclear cells with anti-CD90 coupled to a superparamagnetic pearl. D) Separation of the CD90+ cells by the temporary union of the super-magnetic pearls; the cells go through an electromagnetic column designed by Miltenyi Biotec. E) Harvest of CD90+ cells with some remaining erythrocytes. F) Counting CD90+ cells in the Scepter equipment (Merck Millipore). G) Hydration of scaffold by positive pressure with DMEM medium. H) Seeding of the CD90+ cells in the polyurethane scaffold and sealing with based fibrin glue (Baxter).
Cell seeding in the Polyurethane meniscal scaffold. A) Harvesting of the cells from the cultivation of the pre-expanded CD90+. B) Aliquots 3.3x10^6 cells suspended in 200uL of fiber glue using a 300uL micropipette tip. C) Injection of the cells within approximately 5mm of the scaffold. E) Coating of all faces of the scaffold with fibrin glue. F) The scaffold was submerged and kept in culture for two days. G) Positive calcein staining (green), for the cells within the scaffold after two days in cellular culture.
Polyurethane implant enriched with MSCs and sealed with fibrin glue. A) Implant is manipulated carefully to prevent cell & scaffold damage. B & C) After arthroscopic estimation of the size of the defect area, the implant is measured in the back table and trimmed 10 mm larger than the required size.
Surgical technique of medial meniscus substitution in the posterior horn with polyurethane implant enriched with MSCs. A) Defect size is estimation with a flexible ruler. B & C) Once the implant is trimmed in the back table this is introduced into the joint using arthroscopic forceps to push the implant into the defect area. D & E) Implant is fixed to the adjacent healthy meniscal tissue with horizontal stitches (all inside technique) and vertical ones to hold it to the capsule and meniscal rim. F) Pump flow is closed, and blood clot is formed over the sutured area. Notice that a PDS suture is placed in the implant to keep the tips outside the joint in order to do not lose the implant inside the joint.
Results

- Ages were similar (37.2 MS-MSC /33.17 MS-A) in a total of 11 vs 6 patients, respectively.

- Significant improvement in all functional scores was observed in both groups at pre-op vs 24 months (p<0.05).

- Cartilage status by T2-maping at 3 & 24 months MS-MSC (f=49.5± 2.6 vs 51.1±2.6; t=47.17±3.7 vs 40.8± 1.6) and MS-A (f=47.1± 2.8 vs 41.7±2.6, t=46.25±6.3 vs 47.4±1.6) in the femur & tibia, respectively.

- Comparing T2-maping in femur (MS-MSC 51.1±2.6 vs MS-A 41.7±2.6, p=0.04) and tibia (MS-MSC 40.8± 1.6 vs MS-A 47.4±1.6, p=0.02).
Evaluation of the cartilage status after meniscal substitution by T2-mapping. In the acellular group the tendency in the tibial plateau was towards decrease significantly from 3 to 12 months. Cartigram values in the MSCs group slightly increased at 9 months but at 12 months returns to the initial measurements. This difference tends to be significantly lower in acellular patients than cellular implants at final outcome ($p = 0.18$).
The T2-mapping values of the femoral condyle and tibial plateau were compared intra-group and between groups by gender founding significantly lower in the tibial plateau compared to femoral condyle in PIA group at 6 months. Similar results were observed in PIM group for males at 3, 9, and 12 months while in females those differences were reflected only at 3 and 6 months in the same group.

<table>
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<tr>
<th>Gender</th>
<th>T2-mapping</th>
<th>3m</th>
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<td>p</td>
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<tr>
<td>Males</td>
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<td>48.4 ± 5.3</td>
<td>45.9 ± 5.0</td>
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<td>Femoral</td>
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<tr>
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<td><strong>0.03</strong></td>
<td>0.29</td>
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</table>
Conclusions

- No deterioration in cartilage was observed from 3 to 24 months in both groups (p>0.05), however when comparing scaffolds with and without cells T2-mapping was significantly stable in the femur for MS-A and tibial plateau for MS-MSC.

- No deterioration of cartilage status was observed in any of the groups after 24 months.
References


