Arthroscopic fixation of matrix associated Autologous Chondrocyte Implantation-
Joint compression forces following biodegradable pin fixation

1Herbert M; 2Zelle S; 3Schanz S; 4Raschke MJ; 5Petersen W; +1Zantop T

+1Department of Trauma, Hand, and Reconstructive Surgery, University of Muenster, Germany,
2Department of Traumatology, Martin Luther Hospital, Berlin, Germany
thore.zantop@ukmuenster.de

Introduction: Several studies evaluate the clinical outcome of matrix autologous chondrocyte implantation (m-ACI) and compare them to microfracture of the chondral defects (1,2). However, there may be interference of the results due to the increased morbidity of open m-ACI fixation technique. Recently arthroscopic techniques for m-ACI fixation have been described (3,4). Besides transosseous suturing technique (3), a fixation technique using biodegradable pin fixation can be used (4). A recent biomechanical study has shown significantly increased structural properties of pin fixation when compared to open sutures of the matrix (5). However, arthroscopic pin insertion is technically demanding and a not perpendicular inserted pin may cause increased joint compression forces thus resulting in cartilage damage at the tibial plateau. Aim of the current study was therefore to evaluate joint compression forces following biodegradable pin fixation perpendicular and 30° tilted to the matrix surface. We hypothesize that perpendicular insertion of a biodegradable pin for the fixation will not result in altered pressure distribution of joint compression forces when compared to the intact knee. Furthermore, it was hypothesized that an insertion 30° tilted will result in significantly altered increased joint compression forces.

Methods: In 15 porcine knee joints the lateral femoral condyle was resected leaving the meniscus attachment intact and mounted in 30° knee flexion in a material testing machine (Zwick/Roell, Ulm/Germany). Joint compression forces were recorded using a digital pressure sensor (Novel, Munich/Germany) underneath the medial meniscus and an axial compression of 100 N. The forces were recorded for the intact femoral condyle, standardized cartilage defect of 25 x 20 mm, after matrix associated ACI (BioSeed®, Biotissue, Freiburg/Germany) fixed in transosseous suture technique according to Erggelet and fixed in pin fixation using a biodegradable pin (SmartNail, Conmed Linvatec,16mm) perpendicular and 30° tilted to the matrix surface. This testing protocol allowed multiple testing within one specimen thereby increasing the statistical power. To exclude any interference the order of fixation was randomized. Statistical analyses were performed using a two-factor repeated-measures analysis of variance (ANOVA). The level of significance was set at p < 0.05.

Results: After creation of the standardized cartilage defect, the joint compression forces (824 kPa) were significantly increased when compared to the intact knee joint (564 kPa) (Fig.1). After m-ACI implantation using the transosseous and perpendicular pin fixation, the joint compression forces of the cartilage defect was significantly decreased. No significant differences were found in maximal contact pressure between the intact, the transosseous fixed and perpendicular pin fixed matrices (p>0.05). Contact pressure was 564 kPa for the intact, 581.3 kPa for the transosseous fixed and 630.7 kPa for the perpendicular pin fixed matrices.

Cartilage defect resulted in significantly increased joint contact pressure compared to the intact and reconstructed knees using transosseous and perpendicular pin fixation technique. Joint contact pressure forces after pin fixation using a 30° tilted insertion was a mean of 1740 kPa and significantly increased compared to all other groups (Fig.2).

Discussion: The results support our initial hypothesis and show that a perpendicular inserted pin for the fixation of m-ACIs does not result in significantly increased joint compression forces. The creation of a standardized cartilage damage lead to significantly increased forces at the tibial plateau. Insertion of the matrix and fixation using a transosseous suture technique or perpendicular pin fixation reduced the joint compression forces to the values of the intact knee. A malplacement of the pin however, was shown to significantly increase the joint contact forces. In the clinical practice, an arthroscopic fixation of m-ACI may provide advantages such as decreased morbidity when compared to an open approach. Clinical outcome studies should compare cartilage regeneration using two arthroscopic techniques, i.e. arthroscopic microfracturing and arthroscopic m-ACI. However, arthroscopic fixation of a matrix is technically demanding. Besides arthroscopic measuring of the defect, a tilted pin insertion needs to be avoided. The results of our study suggest significantly increased joint compression forces when the biodegradable pin is not inserted perpendicular to the surface. This may result in cartilage damage at the tibial plateau. To avoid a tilted insertion, the surgeon needs to keep the same angle of the aiming device during drilling and insertion of the pin. Additionally, the knee joint flexion needs to be identical during drilling and insertion. We conclude that both arthroscopic fixation techniques, transosseous suture technique and biodegradable pin fixation may be able to restore the joint compression of the intact knee. Caution needs to be used to avoid a tilted pin insertion since it results in increased joint compression forces. Cartilage lesions at the tibial side following arthroscopic biodegradable pin fixation may be due to technical problems during pin insertion.

Fig. 2: 3d illustration of contact forces following perpendicular pin fixation (a) and 30° tilted pin fixation (b).

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