

# IMPROVING VMO FUNCTION UNLOADS LATERAL CARTILAGE WITHIN THE PATELLOFEMORAL JOINT

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## INTRODUCTION

Patellofemoral pain is commonly attributed to lateral malalignment, which can lead to overloading of the lateral cartilage and subsequent areas of degeneration, or lesions. Impaired function of the vastus medialis obliquus (VMO), as either weakness or delayed activation, is believed to contribute to lateral malalignment. Although physical therapy regimens commonly focus on improving VMO function, the biomechanical benefit of improved VMO function has yet to be established. The current hypothesis is that improving VMO function will unload lateral cartilage, both when the cartilage is intact and in the presence of a lateral lesion.

## METHODS AND PROCEDURES

Ten cadaveric knees were tested in vitro to characterize the influence of VMO function on patellofemoral loading. Each knee was secured to a testing frame with the femur horizontal. Loads were applied to represent the VMO, the vastus lateralis (VL), and the combination of the vastus intermedius, the vastus medialis longus, and the rectus femoris (VI/VML/RF). Loading cables connected to dead weights over pulleys were clamped to the quadriceps muscles at their insertion sites on the patella, with the anatomic orientations of the VMO, VL and VI/VML/RF reproduced on the testing frame.

The quadriceps muscles were loaded to represent a normal quadriceps force

distribution, a weak VMO and a VMO with delayed activation. Previously published muscle extension moments for patients with pain and normal subjects (Makhsous et al., 2004; Zhang et al., 2003) were input into a computational model (Elias and Cosgarea, 2007) to determine the force applied by each muscle for each case. For the normal quadriceps force distribution, 420 N, 116 N, and 60 N were applied through the VI/VML/RF, the VL and the VMO, respectively. For the weak VMO, the applied forces were 432 N, 127 N and 27 N, respectively. The delayed activation case used the same forces as the weak case, except with no force applied by the VMO. All loading conditions were applied at 40°, 60° and 80° of flexion. All tests were repeated after removing the cartilage within a radius of 6 mm from a point at the approximate center of the lateral facet of the patella.

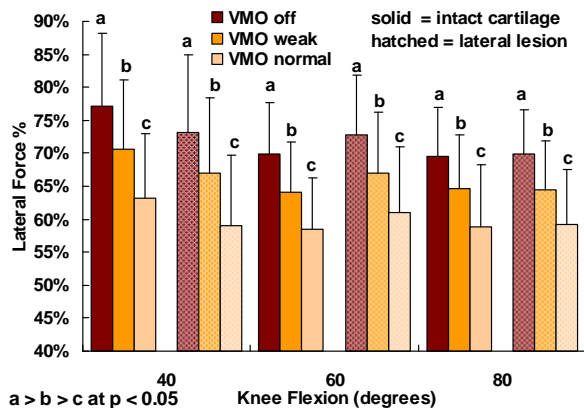
Patellofemoral forces and pressures were measured using a calibrated sensor (K-Scan, Tekscan, Boston, MA). The lateral joint capsule was sectioned to insert the sensor. For each test, with the sensor loaded, the patellar ridge was palpated on the sensor. The maximum lateral and medial pressure and the percentage of the total force applied to the lateral cartilage were quantified. At each flexion angle, a two level repeated measures ANOVA showed if creating a lesion or varying the loading condition significantly ( $p < 0.05$ ) influenced the output. A Student-Newman-Keuls test was used for comparisons between individual loading cases.

## RESULTS

Increasing the force applied by the VMO unloaded lateral cartilage. The lateral force percentage varied significantly between all loading cases at each flexion angle (Fig. 1). Increasing the VMO force decreased the maximum lateral pressure (Fig. 2) and increased the maximum medial pressure (Fig. 3), with significant differences noted at each flexion angle. Creating a lateral lesion significantly increased the maximum lateral pressure at 60° and 80° of flexion.

## DISCUSSION

For intact cartilage, restoring a normal VMO force lowered the maximum lateral pressure to the same level as the maximum medial pressure. For an increase in the VMO force, the increase in the maximum medial pressure was more consistent than the decrease in the maximum lateral pressure due to a slight increase in the total force as the VMO force was increased. Creating a lateral lesion increased the maximum lateral pressure at 60° and 80°. At 40°, the area of contact tended to be distal to the lesion. The decrease in the maximum lateral pressure as the VMO force increased was not more consistent when a lesion was present, although the average decrease tended to be larger due to the elevated pressure caused by the lesion.



**Figure 1.** Average ( $\pm$  standard deviation) lateral force percentage for all tests.

## SUMMARY

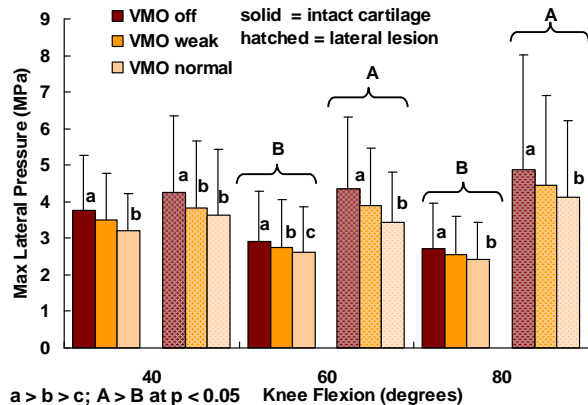
The current results indicate that eliminating VMO weakness and a delay in VMO activation can reduce pressure applied to overloaded cartilage. Improving VMO function can be particularly beneficial when overloading has led to lateral cartilage lesions.

## REFERENCES

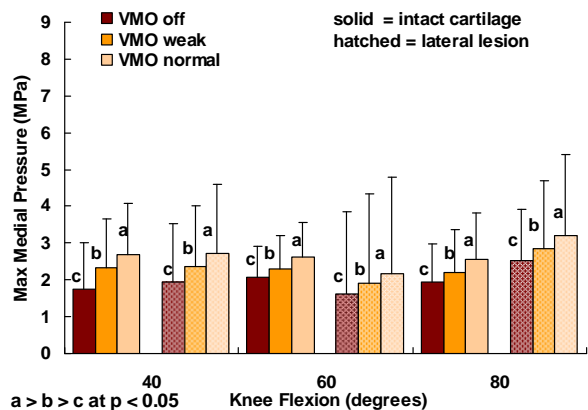
- Elias J, Cosgarea A. (2007). *Sports Med Arthrosc*, 15: 89-94.  
 Makhsous M, et al. (2004). *Med Sci Sports Exerc*, 36: 1768-75.  
 Zhang LQ, et al. (2003). *J Orthop Res*, 21: 565-71.

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**Figure 2:** Average peak lateral pressure.



**Figure 3:** Average peak medial pressure.