INTRODUCTION:
Since the MPFL has been designated as the main passive medial patellar stabilizer, its reconstruction has gained increasing popularity for the treatment of lateral patellar instability. However, it is unclear to what extent the reconstruction restores normal joint biomechanics under physiologically relevant loading conditions. The long term success of this procedure depends upon the ability to restore function, not only in terms of correcting the instability, but also by avoiding an adverse redistribution of joint loads that could progressively lead to osteoarthritis. The goal of this study was to examine whether the contact mechanics of the patellofemoral (PF) joint during activities of daily living depend upon the graft tensioning during MPFL reconstruction and thus evaluate the possible risk of medial joint overload.

METHODS:
The quadriceps and hamstrings of six intact cadaveric knees with physiological trochleas were dissected and assigned to four different muscle groups, which were instrumented with special loading devices. The knees were then reproducibly mounted into a mechanical setup [1] in different flexion angles (12°-57°) with the muscle groups connected to four independent actuators that applied nine different load cases: five that simulated representative loading conditions of level walking (W1-5) and four of stair climbing (SC1-4), based on data acquired from a validated musculoskeletal model [2]. A pressure sensitive sensor (K-Scan #4000, TekScan Inc., South Boston, MA), which was attached onto the trochlea, recorded the PF mean pressure, the contact area and the medial-lateral position of the CoP throughout the trials. The measurement was undertaken in four different conditions: 1. intact knee, 2. after transection of the medial patellofemoral complex, to imitate a lateral patellar instability, 3. after anatomical MPFL reconstruction [3], using a double-bundle technique with a gracilis graft, fixed in 30° knee flexion at the anatomical femoral insertion point, with the lateral patellar edge flush to the lateral trochlea, and 4. after a “high tension” MPFL reconstruction, in which the graft tension recorded for the anatomical reconstruction with the help of a dynamometer was increased by 10 N. A Wilcoxon signed-rank test was used for statistical evaluation (p<0.05).

RESULTS:
The mean PF joint pressure did not differ significantly in any load case after medial transection (p≥0.058), anatomical (p≥0.294) or “high tension” reconstruction (p=0.116) from the mean pressure in the intact joint (Fig. 1a). The PF contact area significantly decreased after medial transection in six out of nine load cases (p≤0.046, Fig. 1b). Furthermore, a significant lateralisation of the medial-lateral CoP was observed in the load cases at 12° knee flexion (p=0.046, Fig. 1c). Both the anatomical (p=0.225) and “high tension” reconstruction (p=0.249) normalized the PF contact area (Fig. 1a). The lateralization of the CoP was also normalized after anatomical MPFL reconstruction, albeit there was a slight overcorrection in two of the load cases (p≥0.046). In the case of the “high tension” reconstruction, however, there was a significant medialization of the medial-lateral CoP in six out of the nine load cases, compared to the intact joint (p=0.028, Fig. 1c).

DISCUSSION:
For the first time the influence of MPFL graft tensioning has been examined under demanding, physiological-like loading conditions of walking and stair climbing, with knee loads up to more than 4xBW. Whilst both surgical techniques led to a convergence to physiological PF biomechanics, the “high tension” MPFL reconstruction was associated with a considerable medialization of the medial-lateral CoP compared to the intact joint. This medialization was evident not only in the load cases at 12° knee flexion, where the transection of the medial patellofemoral complex had resulted in a lateralization, but also in further knee flexion above 39°, where the effect of the transection on the medial-lateral CoP had been indifferent (Fig. 1c). Although the mean pressure after a “high tension” MPFL reconstruction seems to remain unaffected due to a possible load redistribution, the medialization of the medial-lateral CoP involves the danger of a medial PF joint overload during walking and stair climbing. The farther the knee flexion angle deviated from the flexion angle at which the graft was fixed (30°), the more pronounced was the medialization of the CoP (Fig. 1c). This further suggests that the graft tensioning angle may function as a proxy for the modulation of pressure redistribution throughout the range of knee flexion. Limitations of this study include the use of knees without underlying pathomorphology and the possible influence of the sensor on the measurements. However, the results of this study highlight the potential risk of surgical overcorrection and therefore of medial patellofemoral joint overload, if the relative position of the patella to the trochlea and a correct knee flexion angle at graft fixation are not appropriately accounted for intra-operatively.

REFERENCES:

ACKNOWLEDGEMENTS:
This study was supported by the German Research Foundation (DFG WE2233/2-1 and SFB 760).