PATELLOFEMORAL CONTACT LOAD AS A FUNCTION OF THE TIBIAL TUBERCLE MEDIAL-LATERAL POSITION

[1] Jacobus H. Müller, [1]Cornie Scheffer, [2]Pieter Erasmus, [2, 3] Edwin Dillon and [4]Alex Elvin

[1]Department of Mechanical and Mechatronic Engineering, Stellenbosch University

[2]Knee Clinic, Stellenbosch Medi-Clinic

[3] Department of Orthopaedic Surgery, Stellenbosch University

[4]Civil and Environmental Engineering, University of the Witwatersrand

INTRODUCTION

Excessive medial-lateral patellofemoral contact pressure can be alleviated by modifying the position of the tibial tubercle [1]. In this presentation the focus falls on the effect that the tibial tubercle's position in the coronal plane has on: patellofemoral kinematics and kinetics, as well as its effect on patellar tendon and medial patellofemoral ligament load.

METHODS

A volunteer-specific model is setup in the LifeMOD environment (LifeModeler Inc., San Clemente, California, USA) as described previously [2]. In short, Computer Aided Design (CAD) models of the volunteers' lower body are generated from Computed Tomography and Magnetic Resonance Imaging scans. These are then supplemented with muscle-tendon elements and ligaments. The model is manipulated through volunteer-specific motion data. The model has been validated for the case where the volunteer's body motion is simulated as he takes a seat [2].

Three cases were simulated for: 1) the tibial tubercle in the neutral position (PT_{neut}), 2) the tibial tubercle displaced 5 mm laterally (PT_{lat}), and 3) the tibial tubercle displaced 5 mm medially (PT_{med}). Before each simulation the model was allowed to equilibrate. The quadriceps muscles pre-tension was kept constant for each case (411 N) and the loading distribution was as follows: Vastus Lateralis:Rectus Femoris:Vastus Medialis = 2.5:3:2 [1].

Patellar medial-lateral shift and tilt, patellofemoral contact load and patellar tendon (PT) load and medial patellofemoral ligament (MPFL) load were compared for PT_{lat} and PT_{med} as opposed to PT_{neat}. The values for each case were normalized by applying equation 1 and 2.

Eq. 1: $$Property_{case,i} = Property_{case,i} - Property_{case,min} + 1$$

Eq. 2: $$\mathrm{Property}_{case,i} = {\mathrm{Property}_{case,i}}/{\mathrm{Property}_{neutral,i}}$$

With

Property	Patellofemoral kinematical measure or load.
Case	Neutral / medial / lateral patellar tendon.
i	Indices of current value.

RESULTS AND DISCUSSION

The effect of PT_{lat} and PT_{med} as compared to PT_{neut} is considered below (Table 1). The resultant patellofemoral load was smaller for knee flexion <50° for both cases. For knee flexion >60° the lateral patellofemoral load component was greater for PT_{lat} but it was smaller for PT_{med}.

Patellar lateral shift for PT_{lat} was larger for knee flexion <30° and smaller for knee flexion >30°. Patellar lateral shift was larger for PT_{med} for knee flexion >50°. Lateral tilt was smaller for both cases between 0° and 90° knee flexion.

PT load was greater between 0° and 60° knee flexion and smaller for knee flexion >60° for PT_{lat}, while PT load was smaller for PT_{med} between 0° and 90° knee flexion. MPFL load was larger between 0° and 35° knee flexion and smaller from 35° onwards for PT_{lat}, while the MPFL load was smaller between 0° and 35° knee flexion and larger from 35° onwards for PT_{med}.

CONCLUSIONS

The results presented here are only based on the one volunteer's patellofemoral joint. For the PT_{med} case, the medial-lateral patellofemoral load component will decrease at deep knee flexion while it will increase by one and a half for PT_{lat}. This result is similar to the results obtained by changing the Q-angle [3]: A larger Q-angle will increase the lateral component. The results show that the MPFL might be overloaded if the tibial tubercle is shifted medially.

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REFERENCES

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Table 1: Effect of the laterally placed tibial tubercle and medially placed tibial tubercle on patellofemoral joint behaviour

Property	**Knee flexion angle, °**	**PT_{lat} , (SD)**	**PT_{med}, (SD)**
Patellofemoral contact load (resultant)	0	-15.4%	-57%
Patellofemoral contact load (medial-lateral)	90	+57.0 %	-14.5%
Patellar medial-lateral shift	0 and 90 50 to 90	+27.2% and -9.0%	 +15% (2.72)
Patellar medial-lateral tilt	0 to 90	-23% (SD = 7.9)	-11% (SD = 5.91)
Patellar tendon load	0 and 90	+16.7% and -9%	-6.5% and -40%
Medial patellofemoral ligament load	0 and 90	+33.5% and -9%	-40% and +138%