IMPLANTATION OF A TOTAL KNEE ARTHROPLASTY PROSTHESIS IMPOSES ABNORMAL STRAIN ON LOCAL SOFT TISSUES

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INTRODUCTION

Tension in the medial and lateral collateral ligaments is used to regulate joint tightness during total knee arthroplasty (TKA). Despite accurate ligamentous balancing during surgery, many patients experience restricted range of motion after TKA compared to a healthy knee joint [1]. The reason is not well understood. Preoperative range of motion and altered kinematics such as lack of femoral rollback has been suggested [2]. Our hypothesis was that the medial and lateral ligamentous structures and the extensor envelope are tensioned beyond physiological limits after TKA and prevent further flexion. However, the demands placed on these passive tissues are unknown. The purpose of the present study was to investigate the effect on the soft tissue envelope of TKA implantation.

METHODS

Six fresh cadaver knee joints were tested. A novel method was developed for assessment of soft tissue tension in the intact and TKA knee (Fig.1). A stainless steel rod was inserted in the intra-medullary canal of the tibia and secured using 3 screws through the tibial shaft. At the proximal end, the tibial slope was adjustable via a series of inclined plates connected to the inner rod. A 40 N spring was enclosed in the distal aspect of the device below the inner rod to maintain tibio-femoral contact. To insert the device in the knee, 8 mm of bone was resected beneath the tibial plateau (10 mm below the proximal surface). The plateau was then screwed to the bearing surface of the device. Vertical displacement of the device during motion represented the variation in tibio-femoral forces generated by the collateral ligaments and soft-tissue envelope.

Figure 1: Custom device to assess soft tissue tension.

Each knee was mounted in a customized passive motion rig with the femur secured horizontally. A 40 N spring sutured to the quadriceps tendon mimicked the effects of passive muscle tension. Motion was applied in 15 deg increments from 0 to 150 deg flexion. The procedure was repeated after implantation of an LCS rotating platform TKA prosthesis (De Puy), in which the tibial trial was screwed to the bearing surface of the device. Measurements were obtained using the (standard) 7.5 deg tibial slope, and with 0, 5, and 10 deg slopes.

RESULTS AND DISCUSSION

The device position at 45 deg flexion was selected as the zero reference point as minimal tissue tension was expected in mid-flexion. Fig.2 illustrates the displacement of the tibial plateau by soft tissue tension in the natural and TKA knee relative to this point. In both cases, the joint becomes looser (displacement approaches zero) between 0-45 deg. This is markedly more so after TKA. In the intact knee, the joint remains within 1 mm of the zero position until 135 deg and within 2 mm throughout the full range of motion. After TKA, greater soft tissue tension in flexion was indicated by a mean 6 mm displacement at 150 deg. Changing the slope of the tibial plateau did not approach the behaviour of the intact knee.

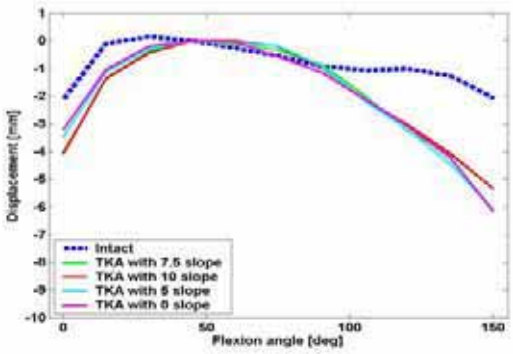

Figure 2: Example of tibial plateau displacement.

CONCLUSIONS

TKA prosthesis implantation imposes additional demands on passive soft tissues beyond 110 degrees and particularly at the extremes of range of motion. This explains the extension deficits and lack of flexion in many knee joints after TKA, and has implications for prosthesis design and implantation technique.

REFERENCES

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