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Unicompartmental arthroplasty of the knee

Cadaver study of tibial component placement

In 30 knee preparations the median posterior inclination (tilt) of the medial tibial plateau was 10° (5°–15°). Following medial compartmental arthroplasty in 20 knees, 10 with horizontal, and 10 with 10° tilted tibial components, the point of articulation was determined radiographically. For the combinations of tibial angle and knee flexion that represent the initial 60 per cent of the stance phase, articulation took place more posteriorly on the horizontal components; there was a correlation between the operation-induced change of the tibial inclination and articulation. Articulation took place far posterior on horizontal components inserted in knees with a steep posterior tilt. We concluded that both the component placement and the preoperative inclination of the tibial plateau determine where on the tibial component articulation takes place. An optimal, central articulation with this set-up is obtained when the component is inserted with the same posterior tilt as that of the original articular surface.

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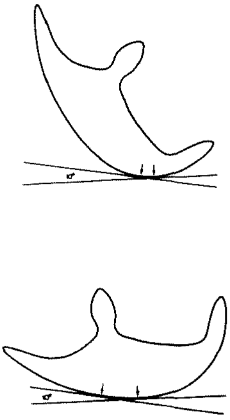
During the stance phase, the tibial articular surface is exposed to loads of 3–4 times body weight (Harrington 1976), the major part of the load being transmitted through the medial compartment (Harrington 1976, Johnson et al. 1980). Replacement of the articular surface by the comparatively small component of a unicompartmental prosthesis therefore makes optimal positioning of the load transmission important to diminish the risk of mechanical loosening (O'Connor et al. 1982). The correlation between the frequency of loosening and obliquely placed components in the horizontal plane has become well established (Cameron et al. 1981, Knutson et al. 1981, Cartier et al. 1982, Shurley et al. 1982). However, no reports have been published on unicompartmental prosthesis articulation and its dependence on the positioning of the tibial component in the sagittal plane.

We have studied the tibio-femoral articulation in medial arthroplasties in cadaveric knees with the aim of deciding the best position of the tibial component.

Material and methods

A flat tibial component acts as a tangent to the articular surface of the femoral component (Figure 1). Posterior tilting of the component at a given flexion makes the point of articulation move forward on the tibial component. As the radius of the femoral component peaks anteriorly, the difference in the distance from the point of articulation to the frontal edge of the tibial component will be at its greatest at extension of the knee.

The inclination of the medial and lateral tibial plateau was measured in 30 cadaver knees, removed in the autopsy room and stored at −18°C until use. Fol-



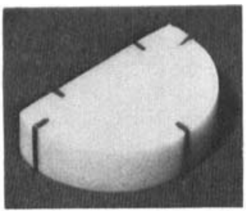


Figure 1. A flat tibial component acts as a tangent to the articular surface of the femoral component (see text).

Figure 2. The tibial component was made of Teflon and provided with five lead markings.

Table 1. Inclinations of the medial and lateral plateaux in 30 cadaveric knees

Tibial plateau	Degree of inclination							Median inclination
	3-4	5-6	7-8	9-10	11-12	13-14	15-16	
	Number of joints							
Medial	–	3	9	7	4	6	1	10°
Lateral	2	9	8	8	1	1	1	8°

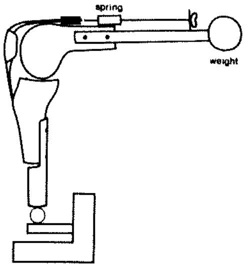


Figure 3. Fixation rig.

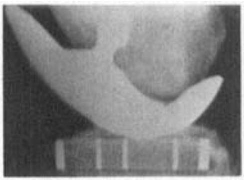


Figure 4. Inserted component. Knee and fluoroscope adjusted to present the upper edge of the five lead markings on a straight line.

lowing levelling of the area toward the eminentia, the slope from the anterior to the posterior gristly edge of the plateau was measured in relation to the longitudinal tibial axis in the sagittal plane (Table 1). The median inclination of the medial plateau was 10° (5°–15°), and of the lateral plateau 8° (4°–15°) ($p < 0.0025$).

Twenty cadaveric knees with preserved joint capsule and knee ligaments were used for the arthroplasties. The medial arthroplasty was performed through a medial parapatellar incision using a femoral component from the Richard's® modular prosthesis and a flat tibial component made of Teflon with the same shape and size as the original product. Five small lead slabs were inserted into the edge of each component (Figure 2), two marking the longest anterior-posterior extension. The surfaces of the slabs were ground to lie flush with the component surface. The tibial plateau was prepared to allow insertion of a component of the greatest possible size with preservation of a narrow bone edge at the periphery of the prosthesis, and it was secured so that the posterior edge did not exceed 4 mm. All components were positioned at right angles to the longitudinal axis of the tibia in the frontal plane, in 10 knees also in the sagittal plane. In the remaining 10 knees, the components were tilted 10° posteriorly.

Proper component positioning was ensured by use of two T-shaped instruments. The flat cross pin in one was at right angles, and in the other at an angle of 100° to the long leg of the instrument. A thin metal pin was inserted from the eminentia area in the longitudinal tibial axis, and by resting the short leg of the instrument on the component surface, positioning was controlled by ensuring that the long leg was parallel to the longitudinal axis in both planes.

The knee was mounted in a rig (Figure 3), the desired flexion being obtained by a balanced pull on the quadriceps tendon. Each knee was examined under unloaded conditions (the femur fixation apparatus only) and with a 4-kg load, applied 25 cm from the medial epicondyle of the femur.

The tibia was positioned at 60°, 75° and 90° angles to the horizontal plane (tibial angle). Flexion angles of 0°, 10°, 20°, 30°, 45°, 60°, 90° and 105° were measured at the tibial angle 90°. Flexion of 0°, 10° and 20° was measured at the tibial angles 60° and 75°.

A radioscope (Phillips BV 22) with a 40-cm focal distance was adjusted to show the upper edge of the lead markings on a straight line at mid-screen (Figure 4). The distance from the tibio-femoral contact to the anterior edge of the tibial component was measured on the screen, allowing for magnification in relation to a 34-mm component. Reproducibility on measuring was 1.3 mm in double readings and double angular adjustment under loaded and unloaded conditions.

At arthroplasty, the preoperative inclination was changed to either 0° or 10°. In 12 knees, six with horizontal and six with posteriorly tilted components, the relationship between the inclinational change ($\Delta(I_{preoper.} - I_{postoper.})°$) and the distance from the point of articulation to the anterior edge of the component was investigated.

Student's *t*-test was used to establish significant differences between the femoro-tibial articulations at the two positions of the component. Regression analyses were undertaken to investigate the relation between articulation and the change in inclination. The regression lines were calculated using the formula: $y = ax + b$.

Results

The articulation on the loaded and unloaded components at the three tibial angles was identical at all flexions, and at a given flexion a change of the tibial angle did not induce changes in the articulation. Consequently, only results obtained in unloaded knees at the tibial angles 60° and 90° will be described.

The articulation took place more posteriorly on the horizontal than on the tilted components. At the tibial angle 90°, the difference

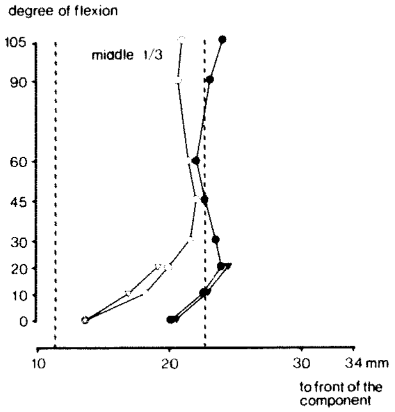


Figure 5. The average distance from the point of articulation to the anterior edge of the tibial component for the 10 knees with horizontal components (● —— ● tibial angle 90°, ▼——▼ tibial angle 60°) and for the 10° tilted components (○ —— ○ tibial angle 90°; ▽——▽ tibial angle 60°). SEM deviation 1.2–1.9 mm.

was significant at 0 ($p < 0.005$), 10 ($p < 0.02$), and 20 ($p < 0.05$) degrees of flexion, and at the tibial angle 60° at all flexions ($p < 0.01$) (Figure 5).

Figure 6 shows the points of articulation in relation to the preoperative inclination for the 12 knees at flexion 0° and tibial angle 90°. Relating the operation-induced change ($\Delta(I_{\text{preoper.}} - I_{\text{postoper.}})°$) at this particular combination with the point of articulation revealed a significant correlation between these parameters (Figure 7). This correlation was significant at flexions 0–20° at both tibial angles (Table 2).

The intersection of the regression lines and the x-axis represents the point of articulation at a given flexion, provided the component tilting was similar to that of the plateau prior to operation; such placement would cause articulation on the central part of the component (Table 2; x-values for $y = 0$).

Discussion

In the present study, a flat tibial component was used, allowing the greatest rotational freedom (O'Connor et al. 1982). Further, with the technique used, only a flat component would allow an accurate determination of the point of contact on the tibial component.

The tibial component is commonly placed horizontally (Cartier et al. 1982, Lindstrand et al. 1982, Mallory & Danyi 1982, Wigren &

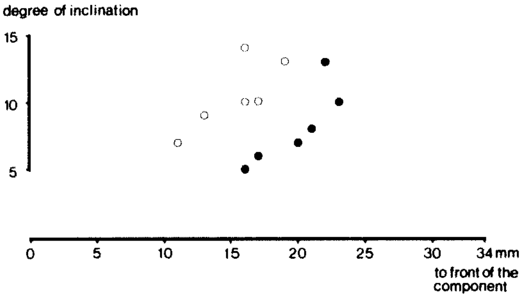


Figure 6. Relationship between the preoperative inclination and point of articulation at 0° flexion and tibial angle 90° for six knees with horizontal (●) and six knees with tilted (○) components.

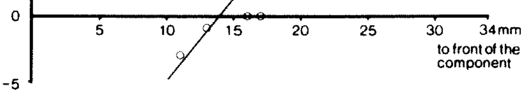


Figure 7. Regression line for the relation between the operation-induced change in inclination and the point of articulation for the tibial angle 90° and flexion 0°.

Table 2. Characteristics of the regression lines with significant correlation. The lines were calculated from the formula y = ax + b; r is the correlation coefficient

Tibial angle	Degree of flexion	a	b	r	x±SD mm for y=0	p<
60°	0	1.03	−14.0	0.78	13.6±2.4	0.005
	10	1.07	−18.0	0.83	16.8±2.2	0.001
	20	0.85	−14.7	0.76	17.3±2.6	0.005
90°	0	1.18	−16.8	0.88	14.0±1.9	0.001
	10	1.33	−23.9	0.83	18.4±1.8	0.001
	20	0.98	−17.8	0.71	18.2±2.6	0.01

Amici 1982), although slight posterior tilting has also been used (Marmor 1979, Insall & Anglietti 1980, Scott & Santore 1981). As the median inclination of the medial plateau in the present study was 10°, it was decided to compare articulation at this component placement with that at horizontal placements. In accordance with the fact that a flat tibial component acts as a tangent to the femoral prosthesis, articulation took place further posteriorly on horizontal than on tilted components, but the difference was only significant for flexions 0–20°, corresponding to the smaller radius of the articulating part of the femoral component at more pronounced flexions.

Articulation in the medial compartment of the intact knee is confined to a small central area of the tibial plateau (Hungerford et al. 1982). Our regression analyses demonstrated that a similar articulation could be expected if the tilting of the inserted tibial component was the same as that of the plateau before operation.

By roentgenstereophotogrammetric analyses, Ryd et al. (1983) demonstrated a posterior tilt in five out of six horizontally inserted components in a 2-year follow-up investigation. It was suggested that the tilt was due to a nut-cracker phenomenon, but it could perhaps rather be explained by continued sinkage caused by posteriorly loaded horizontal components. The tibial angle shifts from 60° to 90°, and knee flexion in the range 0–20°, during the initial 60 per cent of the stance phase (Kettelkamp & Nasca 1973, Inman et al. 1981, Blümlein et al. 1982). This phase yields the greatest loads, which are largely transmitted through the medial compartment (Harrington 1976). At just these combinations of tibial angles and flexions, we found more posterior articulation on horizontally placed components.

We conclude that both the placement of the tibial component and the preoperative inclination of the tibial plateau determine where on the tibial component articulation takes place. An optimal, central articulation is obtained when the component is inserted with the same posterior tilt as that of the original articular surface.

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