

Unicompartmental arthroplasty of the knee

Cadaver study of the importance of the anterior cruciate ligament

The tibiofemoral articulation on horizontal and 10° tilted tibial components was examined radiographically in 20 cadaver knees after lateral arthroplasty, and after cutting the anterior cruciate ligament in 10 knees with medial and 10 with lateral arthroplasty. Articulation took place more posteriorly on the horizontal components at any degree of flexion examined; a correlation was found between the operation-induced change in the inclination of the lateral tibial plateau and the point of articulation. Based on the regression equations, the expected point of articulation on an arbitrarily chosen component placement could be calculated for any degree of flexion provided the preoperative inclination was known. Cutting the anterior cruciate ligament caused articulation to move posteriorly on the tibial component at both medial and lateral arthroplasty. We concluded that it was possible to estimate the tilt of the tibial component that was required to avoid marginal articulations when the preoperative slope of the tibial plateau was known. Absence of the anterior cruciate ligament seems to contraindicate unicompartmental arthroplasty.

Jens T. Møller
Rainer E. Weeth
Johnny Ø. Keller
Strange Nielsen

Laboratory of Biomechanics,
Orthopaedic Hospital, Århus,
Denmark

Correspondence:
Vilhelm Bechsvej 30,
DK-8260 Viby I, Denmark

The relationship between the position of the tibial component in the frontal plane and the risk of mechanical loosening has been established in several studies (Jones et al. 1981, Jónsson 1981). Experimentally, we found insertion of a tibial component by medial arthroplasty with a tilt corresponding to that of the plateau before the operation to result in a central articulation on the component (Møller et al. 1985). A similar technique was used in the present study to determine the tibiofemoral articulation after lateral arthroplasty, and to examine the influence of the anterior cruciate ligament on articulation after medial and lateral arthroplasty with insertion of horizontal or 10° tilted tibial components.

axial rotational stability were measured pre- and postoperatively with a goniometer tracing the mobility pattern by extension-flexion during application of a constant moment (Nielsen et al. 1984).

In 10 knees with medial and 10 with lateral arthroplasty, the anterior cruciate ligament was cut, horizontal components being inserted into one half and tilted components into the other half of the respective arthroplasties.

In 12 knees with lateral arthroplasty, six with horizontal and six with tilted components, the relationship between the operation-induced change in the inclination ($\Delta(I_{preoper} - I_{postoper})^\circ$) and the tibiofemoral articulation was examined. After cutting the cruciate ligament, the joint was only examined under loaded conditions.

For a detailed description of the experimental technique and the statistical analysis, see Møller et al. (1985).

Material and methods

Cemented, lateral arthroplasty was performed in 20 knees, 10 with horizontal and 10 with 10° tilted tibial components. The aim of the operation was to attain the same degree of ligament stability as was found preoperatively. In four knees with horizontal and four with tilted components, both varus-valgus and

Results

On correct alignment there were no significant differences between the pre- and postoperative mobility patterns.

The articulation after lateral arthroplasty in the unloaded preparations at the tibial angle

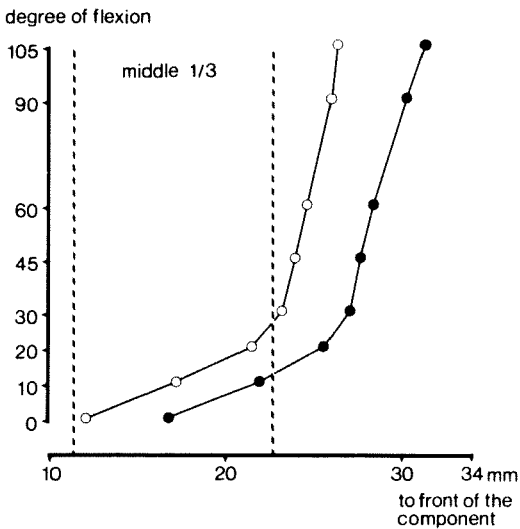


Figure 1. Relationship between the degree of flexion and the distance from the point of articulation to the anterior edge of the tibial component in 20 unloaded knee arthroplasties, 10 with horizontal (●—●), and 10 with 10° tilted (○—○) components.

90° is shown in Figure 1. With both component placements a progressive posterior shift of the point of articulation was seen with increasing flexion. At all flexions the point of articulation was situated further posteriorly on horizontal than on tilted components. During flexion of 0–90° in the unloaded preparations, the difference in the average distance from the point of articulation to the front of the component was 13.5 mm on horizontal and 14.1 on tilted components.

Changing the tibial angle from 90° to 60° did not change the articulation (only flexions at 0–

20° were investigated at the tibial angle 60°).

The load caused articulation to move slightly posteriorly at both component placements and tibial angles, although the difference was only significant at 30° and 45° of flexion at the tibial angle 90°.

There was a significant correlation between the operation-induced change in the inclination ($\Delta(I_{\text{preoper.}} - I_{\text{postoper.}})^{\circ}$) and the tibiofemoral articulation at all flexions at the two tibial angles. Regression line characteristics for each degree of flexion for the unloaded preparations are shown in Table 1. The intersection of the regression line and the x-axis (x-values for $y=0$ in Table 1) represents the point of articulation anticipated on insertion of the tibial component at the preoperative inclination. As the regression equations express the relationship between the change in inclination and the point

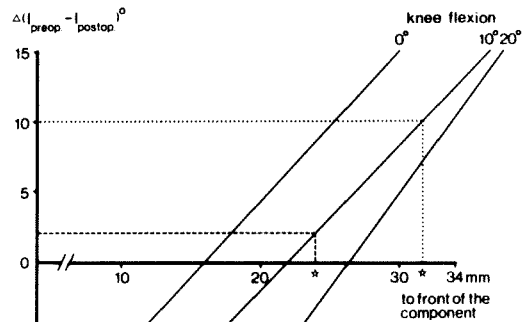


Figure 2. Regression lines at the tibial angle 60° in the unloaded preparations after lateral arthroplasty. (*) marks the point of articulation that could be expected had a horizontal (.....), respectively 8° tilted component (-----) been inserted in a knee with an inclination of 10° (see text).

Table 1. Characteristics of the regression lines for the unloaded knee joints

Tibial angle	Degree of flexion	a	b	r	$x \pm \text{SD}$ mm for $y=0$	$p <$
90°	0	1.32	-19.0	0.84	14.4 ± 1.9	0.001
	10	1.35	-26.8	0.83	19.9 ± 1.9	0.001
	20	1.46	-35.6	0.83	24.4 ± 1.7	0.001
	30	1.87	-48.7	0.88	26.0 ± 1.2	0.001
	45	1.44	-38.1	0.75	26.6 ± 1.9	0.005
	60	1.45	-39.4	0.70	27.2 ± 1.9	0.02
	90	1.05	-29.3	0.63	27.9 ± 2.6	0.05
	105	0.93	-26.4	0.66	28.4 ± 2.9	0.02
60°	0	1.08	-17.5	0.81	16.2 ± 2.4	0.005
	10	1.04	-23.0	0.83	22.1 ± 2.5	0.001
	20	1.35	-35.5	0.87	26.3 ± 1.7	0.001

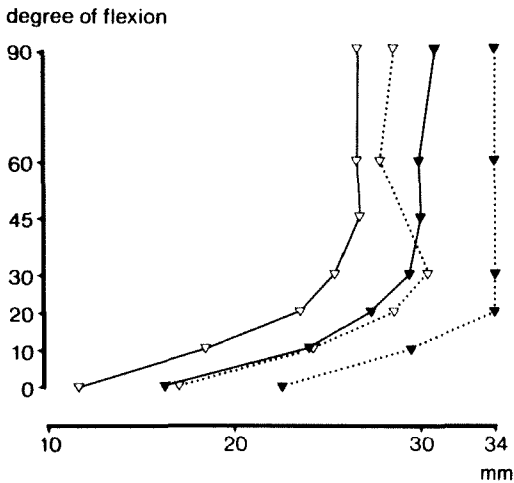


Figure 3. Articulation after lateral replacement at the tibial angle 90° on five horizontal tibial components before (▼—▼) and after (▼.....▼) cutting the anterior cruciate ligament, and on five tilted components before (▽—▽) and after (▽.....▽) the cutting.

of articulation, it was possible, at each degree of flexion, to calculate the anticipated point of articulation on an arbitrarily chosen component placement at a given preoperative inclination. Figure 2 shows the regression lines for the tibial angle 60°. By insertion of e.g. a horizontal component (postoperative inclination = 0°) in a knee with an inclination of 10°, the point of articulation at 10° of flexion is calculated from $y=1.04x-23.0$ (Table 1). For $y=10$,

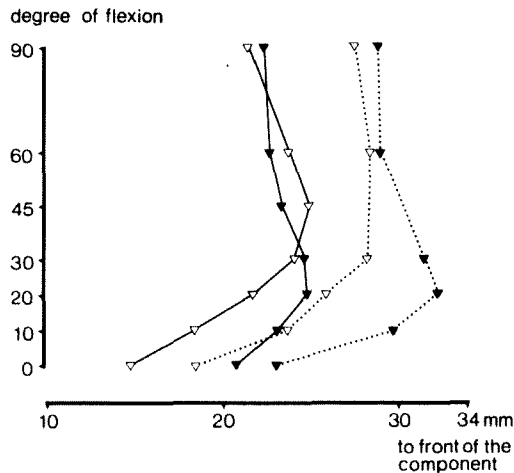


Figure 4. Articulation after medial replacement at the tibial angle 90° on five horizontal components before (▼—▼) and after (▼.....▼) cutting the cruciate ligament, and on five tilted components before (▽—▽) and after (▽.....▽) the cutting.

$x=31.7\pm 2.5$ mm, or only 2 mm from the posterior margin of the component. Insertion of a component tilted 8° ($\Delta(I_{\text{preoper.}}-I_{\text{postoper.}}) = 2^\circ$) yields $x=24.2\pm 2.5$ mm (the x -values are indicated by * in Figure 2). The difference corresponds to about 1/4 of the extension of the component.

After both medial and lateral arthroplasty, cutting the cruciate ligament made articulation move posteriorly. At the tibial angle 60° the difference was not significant on the tilted components at flexion 0° after medial and at 0 and 10° after lateral replacement.

At the tibial angle 90°, the difference on the tilted components after lateral replacement was insignificant at 60° and 90° of flexion (Figure 3), and articulation took place on the posterior edge of the horizontal components during flexion of 20°–90°. In the medial replacements the difference before and after cutting was significant for all flexions with both component placements (Figure 4).

Discussion

In lateral arthroplasties articulation took place further posteriorly on horizontal than on tilted components, as was found also in the medial compartment (Møller et al. 1985); this difference was significant at all degrees of flexion in lateral replacements.

During flexion of the normal knee, the tibiofemoral contact moves further posteriorly on the lateral than on the medial plateau (Draganich et al. 1984). Hungerford et al. (1982) thus recorded a displacement of 6 mm in the medial and 12 mm in the lateral compartment during 0–40° of flexion, causing an automatic internal rotation of the tibia about the femur. Posterior displacement of more than 1 cm of the articulation during flexion calls for a very precise placement of the tibial component; the position should be as far posterior as possible, and, as demonstrated by the present study, the use of horizontal components involves the greatest risk of marginal loads. By inserting the tibial component with the preoperative inclination (Table 1), articulation was found to be the same as in the intact knee, causing load transmission to the strongest part of the sub-jacent bone (Hvid & Jensen 1984).

The fully extended knee exhibits rotational stability, and the first part of flexion allows only minimal rotation (Nordin & Frankel 1980). An assessment based on the recorded mobility patterns revealed that proper alignment ensured the same level of stability after lateral replacement as existed in the intact knee. It is therefore to be expected that the points of articulation found in our study, corresponding to the first 60 per cent of the stance phase, should not substantially deviate from those obtained in clinical conditions.

Only a few authors have described the condition of the anterior cruciate ligament in connection with unicompartmental arthroplasty (Marmor 1977, Andersen 1979, Laskin 1979, Kohlstad et al. 1980). We found that with both medial and lateral replacement, absence of the ligament led to considerable displacement of the articulation and a risk of posterior, marginal loads on the tibial component.

Our investigation has shown that it is possible to calculate the inclination of the tibial component required to avoid marginal articulations when the preoperative slope of the tibial plateau is known. Absence of the anterior cruciate ligament seems to contraindicate unicompartmental arthroplasty.

References

- Andersen, J. L. (1979) Knee arthroplasty in rheumatoid arthritis. *Acta Orthop. Scand.*, Suppl. 180.
- Draganich, L. F., Andersson, G. B. J., Andriacchi, T. P. & Galante, J. O. (1984) The influence of the cruciate ligament on femoro-tibial contact movement during knee flexion. *Trans. O. R. S.* **30**, 29.
- Hungerford, D. S., Kenna, R. V. & Krackow, K. A. (1982) The porous-coated anatomic total knee. *Orthop. Clin. North Am.* **13**, 103–122.
- Hvid, I. & Jensen, J. (1984) Cancellous bone strength at the proximal human tibia. *Eng. Med.* **13**, 21–25.
- Jones, W. T., Bryan, R. S., Peterson, L. F. A. & Ilstrup, D. M. (1981) Unicompartmental knee arthroplasty using polycentric and geometric hemi-components. *J. Bone Joint Surg.* **63-A**, 946–954.
- Jönsson, G. T. (1981) Compartmental arthroplasty for gonarthrosis. *Acta Orthop. Scand.*, Suppl. 193.
- Kohlstad, K., Sahlstedt, B. & Wigren, A. (1980) Extension deficit and lateral instability in degenerative disease of the knee. *Acta Orthop. Scand.* **51**, 667–672.
- Laskin, R. (1979) Total knee replacement. *Orthop. Clin. North Am.* **10**, 223–247.
- Marmor, L. (1977) *Reconstruction of knee joint following trauma*. Matthew Bender & Company, New York.
- Møller, J. T., Weeth, R. & Keller, J. Ø. (1985) Unicompartmental arthroplasty of the knee. Cadaver study of tibial component placement. *Acta Orthop. Scand.* **56**, 115–119.
- Nielsen, S., Kromann-Andersen, C., Rasmussen, O. & Andersen, K. (1984) Instability of cadaver knees after transection of capsule and ligaments. *Acta Orthop. Scand.* **55**, 30–34.
- Nordin, M. & Frankel, V. H. (1980) Biomechanics of the knee. In: *Basic biomechanics of the skeletal system*. (Eds. Frankel, V. H. & Nordin, M.), pp. 113–148. Lea & Febiger, Philadelphia.