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Total condylar knee arthroplasty

Prosthetic component positioning and radiolucent lines

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Prosthetic positioning and overall postoperative alignment were studied in 138 consecutive total knee replacements, using the Insall/Burstein® total condylar knee system. Overall alignment was within 7 ± 5 degrees of valgus in 63 per cent of the knees, while tibial component positioning was within 4 degrees of tilt in any direction in 53 per cent of the knees.
A radiolucency index incorporating width and extent of radiolucent zones at the tibia was shown to progress from 3 months to 2 years postoperatively. The radiolucency index 2 years postoperatively was higher with postoperative varus alignment in the rheumatoid arthritis group; a tibial component tilt of more than 4 degrees in any direction increased the radiolucency index in both treatment groups.

Key words: joint prosthesis; knee joint; knee prosthesis; radiography.

In total knee replacement of the non-hinged, semi-constrained design, mechanical loosening involves the tibial component much more often than the femoral component (Insall et al. 1976, Cameron & McNeice 1981) and, although the problem of mechanical loosening is a multifactorial one, its occurrence can often be ascribed to poor angular or rotational positioning of the prosthetic components (Rand & Coventry 1980, Goldberg & Henderson 1980, Cameron & McNeice 1981). For a specific type of prosthesis, a relationship between prosthetic positioning and clinical score has been established (Lotke & Ecker 1977). It is important, therefore, to evaluate current knee replacement designs with respect to the prosthetic component positioning achieved.

This paper reports on postoperative knee alignment and angular positioning of prosthetic components in 138 consecutive knee replacements using the standard Insall/Burstein® total condylar knee system. Incidents of mechanical loosening and the extent of radiolucent zones beneath the tibial plateau at the 2-year follow-up were analyzed with respect to component positioning, overall knee alignment and the type of knee pathology.

Material and methods

General

The material consisted of 138 consecutive total knee replacements (TKR) in 106 patients; thus, 32 patients had bilateral TKR. Diagnosis, sex and age-range are summarized in Table 1. The rheumatoid arthritis group included one patient with psoriatic arthritis. The miscellaneous group included one patient with haemophilia A and one patient suffering from the sequelae of a severe tibial plateau fracture. Several orthopaedic surgeons and residents on the staff performed the surgery during the period November 1979 through March 1981. The operative technique followed that of the originators (Insall & Burstein 1979). Severe malignment was corrected by the appropriate extensive soft tissue release. One patient with septic loosening of the implants was excluded from the study.

Table 1. Summary of diagnoses, sex and age-range

Group	No. of knees	No. of patients	Sex-ratio	Age	
			♀/♂	median	range
Osteoarthritis	64	56	3.7	70	30–81
Rheumatoid arthritis	71	48	3.4	59	24–71
Miscellaneous	3	2	1.0	48	41–55

Roentgenological evaluation

Routine non-weightbearing anteroposterior and lateral radiographs obtained at the 2-year follow-up were used. The angles measured are shown in Figure 1. When the prosthetic component is tilted in varus, the angle is given a negative sign. The overall knee alignment can then be calculated from:

$$\theta = \alpha + \beta$$

presuming that both prosthetic condyles are in contact when the knee is weightbearing. One rheumatoid knee was excluded from this part of the study because of poor X-ray quality.

Radiolucent lines beneath the tibial component were measured on the anteroposterior X-rays. The thickness (T) and extension in per cent (E) of the lines were measured separately beneath the medial and lateral plateaus and around the central fixation post. A radiolucency index was created by summing the products TxE from the three zones. Radiolucent lines may be present soon after the insertion of the prosthesis (Ahlberg & Lindén 1977). These early radiolucencies were not taken into consideration since it was assumed that they would show a stochastic distribution throughout the material. A meaningful analysis would require that there is a progression of radiolucent zones beyond the immediate postoperative period. To check this concept, the progression of the radiolucency index was investigated in 11 patients with osteoarthritis and nine patients with rheumatoid arthritis. The radiolucency index was measured on X-rays obtained 3 months postoperatively and at the 2-year follow-up. At 3 months the radiolucency index (shown as median (interquartile range)) was 63 (25–100), while at 2 years it was 150 (78–300) in the same knees. By Pratt's method of paired comparison (Rahe 1974),this difference is highly significant ($P < 0.01$), showing a progressive increase in the radiolucency index. Regression of radiolucencies present at 3 months was not observed. In accordance with other accounts (Ahlberg & Lindén 1977, Cameron & Freeman 1979), radiolucencies were found to be sparse beneath the femoral components and are not reported here for two reasons: the clinical problem of femoral component loosening is negligible; and radiolucencies are difficult to evaluate since any tilting of the metal components in relation to the X-ray beam would tend to conceal radiolucent zones.

The three knees in the miscellaneous group (Table 1) were not included in this part of the study. One rheumatoid knee was also excluded because of poor quality of the radiographs. Thus, 134 knees were evaluated with respect to the radiolucency index.

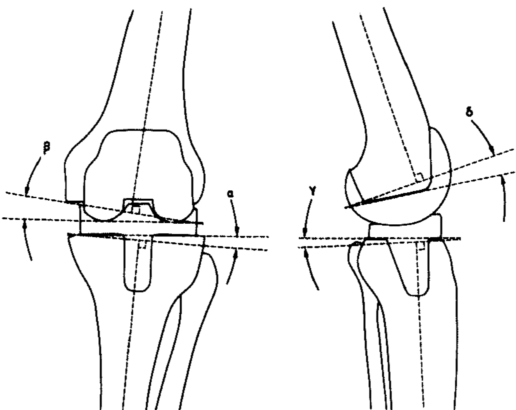

Figure 1. The angles measured on the X-rays were: angular deviation of the base of the tibial component from a line at right angles to the tibial axis (α), and of the femoral component from a line at right angles to the femoral axis (β) on the anteroposterior projection. The same method was applied to measuring angular deviations of the tibial (γ) and femoral (δ) components on the lateral projection.

Clinical evaluation

The patients were assessed according to a 100-point score system (Insall et al. 1976), and the relation between the clinical result and the radiolucency index was studied. It is not the purpose of this paper to give a detailed account of the clinical results obtained.

Statistical evaluation

The two-tailed Mann-Whitney rank-sum test with correction for tied observations was used to compare groups (Siegel 1956), unless otherwise stated.

Results

The postoperative overall alignment of the knees is shown in Figure 2. Sixty-three per cent of the knees were within 7 ± 5 degrees of valgus. There were no cases of excessive valgus, and 15 per cent of the knees were in varus alignment. Preoperative overall alignment was measured clinically and varied between 25 degrees of varus and 20 degrees of valgus. In Figure 3, the relationship between preoperative and postoperative alignment is shown. There is a tendency to undercorrection of varus malalignment and overcorrection of valgus malalignment.

Angular positioning of the tibial components

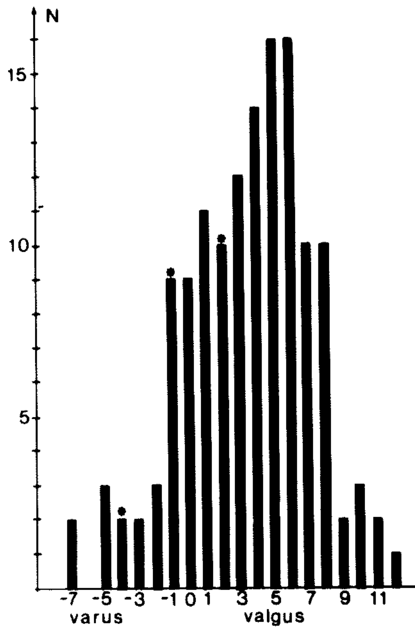

Figure 2. Postoperative overall alignment. Columns with loose component marked with *.

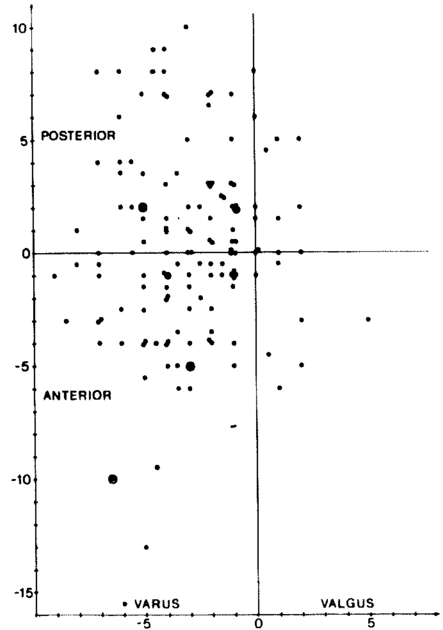

Figure 4. Positioning of the tibial components. Cases with loose component shown with 0.

as measured on the anteroposterior and lateral radiographs is depicted in Figure 4. The aim was to place the component at right angles to the tibial axis. Seventy-one per cent were within 4 degrees of varus or valgus, and 74 per cent were within 4 degrees of anteroposterior tilt. Fifty-three per cent were within 4 degrees of tilt in any direction. Ninety-two per cent of

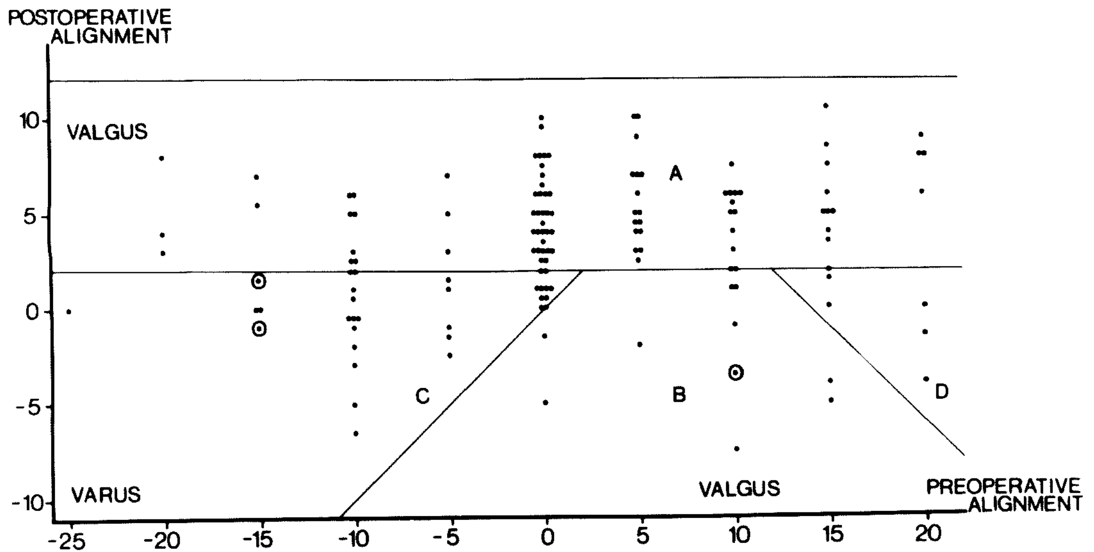

Figure 3. The relationship between preoperative overall alignment. Region A includes cases with acceptable alignment, regions C and D cases with improved alignment (reduced deviation from 7 degrees of valgus), and region B cases with worse than preoperative alignment. Cases with loose component shown with 0

Table 2. The influence of overall alignment on the radiolucency index in the two major treatment groups. Acceptable overall alignment was defined as 7 ± 7 degrees of valgus. The variable is expressed as median (interquartile range)

Group	Alignment	N	Radiolucency index	P
Osteoarthritis	Acceptable	53	100 (37.5–200)	0.10<P<0.20
	Varus	11	100 (100–210)	
Rheumatoid arthritis	Acceptable	58	100 (50–200)	0.01<P<0.02
	Varus	12	175 (150–250)	

Table 3. The influence of tibial component positioning on the radiolucency index. An acceptable position was defined as ±4 degrees of tilt in any of the two directions

Group	Tibial component positioning	N	Radiolucency index	P
Osteoarthritis	Acceptable	34	69 (19–166)	0.02<P<0.05
	Tilted	30	138 (75–200)	
Rheumatoid arthritis	Acceptable	37	100 (13–138)	P<0.001
	Tilted	33	175 (100–288)	

the femoral components were within 7 ± 5 degrees of valgus; the anteroposterior tilt was within ±10 degrees in 93 per cent.

The radiolucency index did not differ significantly between the osteoarthritis group (100 (50–200)) and the rheumatoid arthritis group (125 (50–200), $P > 0.20$). Thirteen per cent showed a radiolucency index of 300 or more, which equal is to a radiolucency zone of 1 mm or more at the entire cement-bone interface. There was no significant difference in the local radiolucency index beneath the medial and lateral part of the tibial component between patient groups. Around the large central post, the local radiolucency index was significantly smaller than beneath the two horizontal areas (Pratt's test, $P < 0.01$).

The relation between overall alignment and the extent of the radiolucent zones is evaluated in Table 2. There was no significant effect of varus alignment in the osteoarthritis group, while in the rheumatoid arthritis group varus alignment was associated with an increase in the radiolucency index. Varus was of any degree beyond zero. Changing the region of acceptable alignment to 7 ± 5 degrees of valgus (disregarding results between 0 and 2 degrees) did not alter the result shown. The tibial component tilt (Table 3) significantly influenced the radiolucency index in both treatment groups. No relationship could be demonstrated between the radiolucency index and the clinical score ($0.10 < P < 0.20$).

Three tibial components loosened (marked on Figures 2–4) during the 2-year period, an incidence of 2.2 per cent. Two of the these occurred in the rheumatoid arthritis group, and one in the osteoarthritis group. Two patients showed varus alignment postoperatively; the third had some instability and varus alignment with weightbearing. All tibial components were in varus tilt; two were in anterior tilt. The mechanism of loosening was a breakdown of the medial tibial plateau, preceded by a progressively widening radiolucent zone.

Discussion

One object of TKR is the reestablishment of normal tibiofemoral alignment. The use of non-weightbearing X-rays does cause some inaccuracy in the estimation of overall alignment in unstable knees. However, good stability was found in almost all knees: 60 per cent were completely stable, 36 per cent showed slight instability between 1 and 5 degrees, and only 4 per cent had instability of 6 degrees or more. Gait analyses have shown that in the normal knee approximately 60 per cent of the total joint load is transferred through the medial part of the knee (Morrison 1970). With varus alignment, there is a further shift of load to the medial side, rapidly approaching 100 per cent. Contrary to the predictions of static analysis (Kettelkamp & Chao 1972), valgus alignment does not have the opposite effect. In most knees with a valgus deformity of up to 20 degrees, more than 50 per cent of the load is transferred medially (Johnson et al. 1980). These data imply that varus alignment after total knee replacement should be avoided, and this view is confirmed by clinical experience (Rand & Coventry 1980). On this background we find it somewhat unsatisfactory that 15 per cent of our patients were in varus postoperatively. About half of the tibial components were within 4 degrees of tilt in any direction. There was a tendency to posi-

tion the tibial component in slight varus and posterior tilt. The femoral component was positioned between 2 and 12 degrees of valgus in 92 per cent of the patients. The anteroposterior tilt of the femoral component is less critical and was within 10 degrees to either side in 93 per cent. Hood et al. (1981) reported on their experience with the Insall-Burstein posterior-stabilized condylar prosthesis and found overall alignment to be within 7 ± 5 degrees of valgus in 80 per cent, compared to 63 per cent in the present material. Also, tibial component positioning was more accurate. One explanation for this finding may be that our patients were operated by several surgeons. It may be concluded from this part of the study that although severe overall malalignment and malpositioning of components were exceptionally rare, a fully satisfactory result including all the parameters studied was obtained in only half of the patients. This finding emphasizes the need for careful and repeated checking during operation.

The extent of radiolucencies beneath the tibial components was found to be related to overall alignment and tibial component positioning. This was more pronounced in the rheumatoid arthritis group (Tables 2 and 3). Varus alignment and a tibial component tilt of more than 4 degrees in any direction (an arbitrarily defined limit) were associated with an increased radiolucency index, except for the influence of varus alignment in the osteoarthritis group. In a study of stress fractures of the tibial plateau after TKR, Rand & Coventry (1980) found that failed prostheses showed varus alignment and a relative varus tilt of the tibial components compared to well-functioning controls. They also found that the tibial component was in anterior tilt in the failed group, while the controls were in posterior tilt. The osteoarthritis group was more resistant to varus alignment than the rheumatoid arthritis group. In rheumatoid arthritis there is a general osteoporosis (Kennedy et al. 1975) with a concomitant loss of bone strength (Behrens et al. 1974). This may explain the difference, but is apparently inconsistent with the finding that there was no general tendency for an increased radiolucency index in the rheumatoid arthritis group. However, by comparing parts of the clinical score concerning mobility we found that the rheumatoid arthritis group was significantly less mobile than the osteoarthritis group, which may balance the influence of weaker bone.

Ahlberg & Lindén (1977) discussed the cause of the radiolucent zones and focussed on three possibilities: mechanical injury to vessels during preparation of the bone, chemical injury and thermal injury. They found no correlation between the occurrence of radiolucent zones and postoperative results, and they argued that the fact that radiolucencies tend to occur at the tibial side where loosening is more common might be incidental. Freeman et al. (1982) explained the progressiveness of radiolucencies by polymethylmethacrylate cement activation of macrophages which may be responsible for resorption of adjacent bone. Other reports support the concept that the frequency of loosening is heavily influenced by the distribution of load (Rand & Coventry 1980, Goldberg & Henderson 1980, Cameron & McNeice 1981). Our findings strongly suggest a mechanical influence on the progression of radiolucent zones, while early radiolucencies may have several explanations.

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