# Effect of a cooled saw blade on prosthesis fixation

## Randomized radiostereometry[a] of 33 knee cases

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Tibial migration in 33 cementless total knee replacements, which were performed with a cooled saw blade vs. a conventional blade, was studied in a randomized prospective study using roentgen stereophotogrammetric analysis (radiostereometry). All cases were clinically successful after 2 years and inducible displacement was smaller in the group operated with the cooled saw blade. This group also had a tendency towards less continuous migration.

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[a] *Radiostereometry* or *radiostereometric analysis (RSA)* replace the term *roentgen stereophotogrammetric analysis (RSA)*. /Editor

Power tools cause high temperatures and heat necrosis (Matthews and Hirsch 1972, Krause et al. 1982, Eriksson 1984, Toksvig-Larsen et al. 1989), which may lead to lysis, micromotion and lack of bony ingrowth (Rhinelander et al. 1979, Cook et al. 1986). By using internally-cooled saw blades, high cutting-temperatures can be avoided (Toksvig-Larsen et al. 1989, 1990, 1991b). We investigated whether this technique would result in a better fixation of tibial endoprosthetic components.

## Patients and methods

33 consecutive cases of knee arthroplasty for arthrosis, 15 men and 18 women, were operated with the P.C.A.™ Modular knee (bossed version) with the aid of the Universal™ Total Knee Instrument System (Howmedica, Rutherford, New Jersey). 2 patients died of cardiac disease after 3 and 6 months. Another 2 patients were missed at the 2-year follow-up; 1 had died and 1, although satisfied, declined to participate in the follow-up. The mean age was 73 (60–87) years, mean weight 78 (49–105) kg. 17 patients were Ahlbäck (1968) Stage III, 12 Stage IV and 4 Stage V. The arthroplasties were all non-cemented and randomized during the operation to have the tibial bone cut performed either (n 15) with a standard 3M Maxi Driver™ oscillating L 122 saw blade or (n 18) with an internally-cooled saw blade (Toksvig-Larsen et al. 1990, 1991b). In 13 cases, the internally cooled blade used was a 2 mm thick prototype made from 2 standard saw blades while, in 5 cases, a 1 mm thick and 15 mm longer saline-cooled saw blade with the same form as the standard blade (Mitab, Sweden). The saline was at room temperature, and supplied by an infusion bag about 1 m over the operation-plane, resulting in a flow of 50–60 mL/min. The tibial component was fixed with three 32-mm screws. The torque necessary to completely bottom the screws was measured using a torque gauge screw driver in 30 cases. Protected weight bearing for 6 weeks was part of the postoperative regimen. However, only 15 patients could comply fully, 5 patients could comply partly and 13 patients could not avoid full weight bearing.

In 17 cases an imprint technique using dental-imprint material (Toksvig-Larsen et al. 1991a) was used to assess the surface characteristics of the tibial cut (8 standard, 6 prototype and 3 Mitab blades). This method allowed measurement of the distance between the uppermost and lowermost points (maximum roughness) and the flatness, defined as the standard deviation of all measured points, obtained by a Zeiss UMC 850.

The patients were followed clinically at 6 weeks, 6 months, 1 and 2 years at which times the Hospital for Special Surgery (HSS) score (Ranawat and Insall 1976) was recorded.

Conventional radiography was done postoperatively, to determine the position of the prosthesis in relation to bone using the PT (prosthesis-tibia medial angle between the prosthesis and the long axis of the tibia in the frontal position) and the PTS (prosthesis-tibia-side posterior angle between the prosthesis and the long axis of the tibia in the lateral projection) angles. At the 6-month control, the HKA (hip-knee-ankle) angle (the medial angle between the lines from

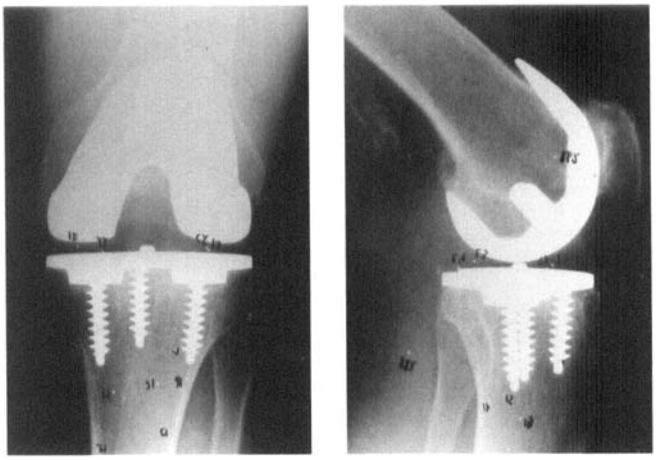

Figure 1. The stress examination where the patient was squatting (position 5). Beyond 60 degrees flexion the A-P radiographic rays were obscured by the buttock of the patients, and thus examination with larger degrees of flexion could not be performed.

the center of the hip and the ankle, respectively, meeting at the center of the knee) was measured (< 180° varus alignment).

### Radiostereometry

During the operation all cases were prepared for RSA measurements (Ryd 1986).

The movements were given either as segment motion, i.e., translation or rotation of the prosthesis, or as point motion, i.e., translation of single prosthetic markers. MTPM—maximum total point motion—i.e., the marker showing the largest 3-D motion was given as a simple way to denote the magnitude of migration. The accuracy of the system in this application has been shown to be 0.3° for single axis rotation, 0.4° for total rotations and 0.2 mm for translation (Ryd 1986).

To study migration, reference radiograms were obtained immediately (1–2 days) after surgery, and at the follow-up visits. To study inducible displacement, stress examinations were done after 1 year. The stress examination consisted of exposures in (1) the supine position, (2) standing and weight-bearing position, (3) outward, and (4) inward rotatory position with a torque of 10 Nm applied to a rotating plate on which the patient was standing, and (5) squatting to about 60 degrees knee flexion (Figure 1). In examinations 2–5, the patients were bearing full weight on the operated leg alone.

The paired *t*-test, the Mann-Whitney *U*-test, the Spearman rank correlation and the Manova test for inducible displacement were used for statistical evaluation.

## Results

All the knees were good or excellent (Table 1). The preoperative walking distance was a mean 450 (25–1000) m with pain from the first step in most of the cases to postoperatively 2000 (100–10000) m and without pain.

At 1 year all tibial components had migrated 1.2 (0.6–2.0) mm in the standard saw group and 1.7 (0.5–4.1) mm in the cooled saw group (n.s.). At 2 years the tibial components had migrated 1.4 (0.8–2.6) mm for the standard saw and 2.0 (0.4–4.5) mm for the cooled saw (n.s.). Subsidence in both groups was 0.4 mm. Nor were there any differences in translation or rotation along and around the 3 axes between the groups (Figure 2). In both groups, migration occurred predominantly during the first 6 weeks, and at this time there was a difference in MTPM between the 2 saw blades (Figure 3) with 0.7 mm for the standard and 1.2 mm for the cooled saw blade ($P < 0.05$ Mann-Whitney *U*), but no differences in translation or rotation along or around the 3 axes. At the 6-month and later follow-ups there were no differences between the 2 groups.

The migration pattern was analyzed regarding initial vs. continuous migration. At 2 years there was a tendency towards less continuous migration in the group operated with the cooled saw ($P$ 0.09). There were no differences in migration between the patients who were able to avoid weight bearing (1.6 mm) compared to the patients with partial weight-bearing (1.7 mm) or the patients who bore full weight immediately after surgery (1.7 mm).

Inducible displacement was found in all cases. The mean inducible displacement was 0.5 (0.2–1.2) mm (MTPM, positions 1–2), 0.6 (0.1–3.1) mm (MTPM, positions 3–4) and 0.4 (0.1–0.8) mm

Table 1. Demographic, clinical, roentgenographic and radiostereometric data

| Case | Sex | Age | Weight | Ahlbäck | HSS | HKA | PT | PTS | MTPM |
|---|---|---|---|---|---|---|---|---|---|
| *Standard saw blade* | | | | | | | | | |
| 1 | F | 74 | 80 | IV | 91 | 177 | 86 | 86 | 1.4 |
| 6 | F | 80 | 71 | III | 95 | 171 | 86 | 88 | 1.4 |
| 7 | F | 62 | 87 | IV | 97 | 187 | 89 | 84 | 1.2 |
| 8 | M | 71 | 76 | III | 96 | 180 | 86 | 85 | 1.4 |
| 10 | M | 78 | 60 | V | 85 | 177 | 87 | 90 | 0.8 |
| 11 | F | 73 | 50 | V | 93 | 177 | 90 | 83 | 1.0 |
| 16 | F | 77 | 83 | III | 91 | 173 | 87 | 80 | 1.0 |
| 18 | M | 63 | 99 | III | 96 | 180 | 87 | 91 | 1.1 |
| 22 | F | 79 | 71 | III | 92 | 175 | 84 | 90 | 1.7 |
| 23 | M | 64 | 98 | III | 98 | 175 | 84 | 82 | 2.8 |
| 24 | F | 78 | | V | 79 | 177 | 85 | 84 | 1.1 |
| 26 | F | 71 | 82 | III | 85 | 180 | 85 | 85 | 1.1 |
| 27 | M | 75 | 75 | IV | 91 | 180 | 85 | 91 | 1.7 |
| 31 | F | 87 | 60 | III | 98 | 181 | 87 | 91 | 1.6 |
| 32 | F | 73 | 82 | III | 98 | 176 | 90 | 89 | 1.0 |
| Mean *SD* | | 74 *7* | 77 *14* | 3.6 *0.8* | 92 *6* | 178 *4* | 87 *2* | 87 *4* | 1.4 *0.5* |
| *Cooled saw blade* | | | | | | | | | |
| 2 | M | 86 | 78 | III | | 174 | 83 | 87 | 1.1 |
| 3 | F | 75 | 49 | IV | | | 84 | 88 | |
| 4 | M | 60 | 75 | IV | 90 | | 85 | 90 | 5.0 |
| 5 | M | 77 | 76 | III | | 182 | 88 | 87 | |
| 9 | F | 66 | 93 | IV | 90 | 180 | 87 | 88 | 0.5 |
| 12 | M | 78 | 73 | III | | | 89 | 85 | |
| 13 | F | 78 | 75 | IV | 88 | 175 | 85 | 82 | 1.3 |
| 14 | M | 70 | 93 | IV | 92 | 182 | 88 | 88 | 1.4 |
| 15 | F | 73 | 70 | IV | 90 | 185 | 92 | 82 | 1.6 |
| 17 | M | 67 | 92 | V | 89 | 182 | 88 | 87 | 1.3 |
| 19 | F | 71 | 70 | IV | 97 | 183 | 86 | 87 | 3.0 |
| 20 | F | 76 | | IV | 92 | 181 | 87 | 83 | 1.6 |
| 21 | F | 75 | 90 | III | 88 | 190 | 91 | 88 | 0.9 |
| 25 | F | 76 | 65 | III | 91 | 180 | 90 | 83 | 1.8 |
| 28 | M | 63 | 105 | III | 98 | 180 | 88 | 85 | 1.8 |
| 29 | M | 66 | 98 | III | 96 | 182 | 87 | 87 | 2.7 |
| 30 | M | 83 | 70 | IV | 98 | 180 | 90 | 85 | 4.1 |
| 33 | M | 63 | 68 | III | 98 | 176 | 85 | 87 | 0.7 |
| Mean *SD* | | 72 *7* | 79 *14* | 3.6 *0.6* | 93 *4* | 181 *4* | 87 *2* | 86 *2* | 2.0 *1.3* |

HSS Hospital for Special Surgery Score–2 year, HKA Hip-knee-ankle angle, PT Prosthesis-tibia angle, PTS Prosthesis-tibia-side angle, MTPM Maximum Total Point Motion - migration 2 year.

(MTPM, positions 2–5). The difference was significant between the saw blade to the advantage of the cooled saw blade in positions 2 and 5, 0.4 mm and 0.5 mm (MTPM), respectively ($P < 0.05$, Manova), as well as regarding translation along the x-axis (0.2 mm and 0.3 mm) and rotation around the z-axis between positions 3 and 4 (0.1° and 0.3°, $P < 0.05$, Manova) (Table 2) .

In 17 cases the preoperative HKA angle was 174° (159°–195°). The postoperative HKA angle was 179° (171°–190°) (n 30 ), 5 patients having an angle which deviated more than 5° from the desired 180°. The PT angle was 87° (83°–92°) and the PTS angle was 86° (80°–91°).

The roughness was 1.42 (1.06–1.81) mm for the standard saw blade and 2.04 (1.43–2.57) mm for the cooled saw blade ($P < 0.01$). The flatness was 0.23 (0.16–0.36) mm and 0.31 (0.26–0.37) mm, respectively ($P < 0.05$). There was no correlation between the roughness or the flatness and the migration. The mean torque for the screws to bottom was 109 (30–193) Ncm and no difference was found between the screws in the lateral, medial or anterior positions. There was no correlation between the torque force and the migration.

## Discussion

Regarding total migration, no effect of the use of cooled saw blade could be found, and the migration of the component where the cooled blade had been used was rather larger. One explanation of this could be that the surface quality of the bone after resection

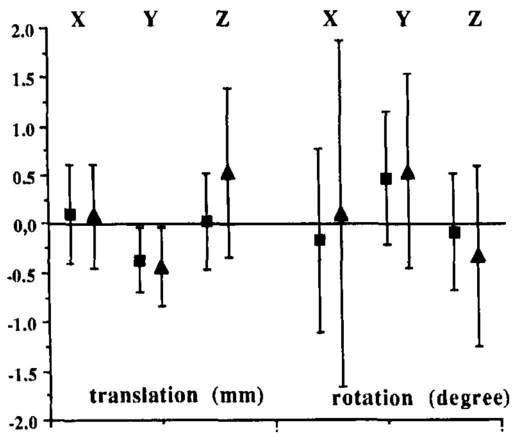


Figure 2. Direction (mean ± SD) of the migration. ▲ cooled blade, ■ standard blade.

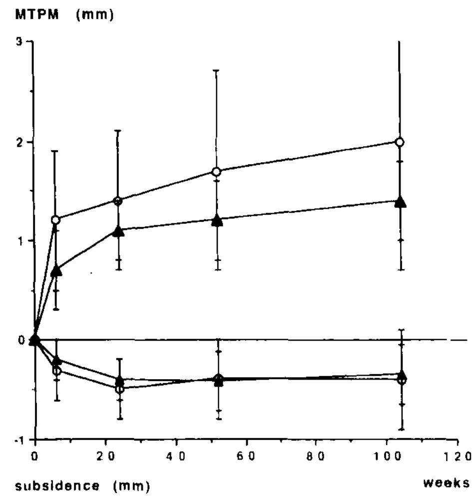


Figure 3. Migration (maximum total point motion ± SD, subsidence ± SD). cooled blade, ▲ standard blade.

Table 2. Results from the stress examination (n 31)

| Position | 1–2 | 3–4 | 2–5 |
|---|---|---|---|
| *Stress MTPM (mm)* | | | |
| Normal saw | 0.5 (0.2–0.8) | 0.7 (0.1–3.1) | 0.5 (0.2–0.8) |
| *P*-value | n.s. | n.s. | < 0.05 |
| Cool saw | 0.5 (0.2–1.2) | 0.4 (0.2–1.5) | 0.4 (0.1–0.7) |
| *Stress x-translation (mm)* | | | |
| Normal saw | 0.2 (0–0.4) | 0.3 (0.1–1.0) | 0.2 (0–0.4) |
| *P*-value | n.s | < 0.05 | n.s. |
| Cool saw | 0.2 (0–0.8) | 0.2 (0–0.4) | 0.2 (0–0.8) |
| *Stress z-rotation (degrees)* | | | |
| Normal saw | 0.2 (0.1–0.3) | 0.3 (0–0.8) | 0.2 (0–0.6) |
| *P*-value | n.s | < 0.05 | n.s. |
| Cool saw | 0.2 (0–0.7) | 0.1 (0–0.4) | 0.2 (0–0.5) |

Statistical analyses using Manova

with the cooled blade was poorer in most cases due to the prototype character of the blade. The prostheses in the group with the cooled blade rested on a more uneven surface and this could lead to larger initial migration.

Recently, the prognostic significance of the pattern of migration, initial vs. continuous, has been established (Ryd et al. 1993, 1995). When analyzing this pattern of migration for each prosthetic component a tendency for less continuous migration for the group with the cooled saw blade was found.

Regarding inducible displacement, this investigation showed a significant, albeit small effect of the cooled saw blade. The use of a cooled saw blade resulted in an interface which was somewhat stiffer and less compliant to external forces. Inducible displacement of 400 µm is still probably too large to be explained by bone elasticity, as for example shown by a mechanically coupled prosthesis (Shimagaki et al. 1990). Most probably such prostheses could not have significant areas of bone ingrowth.

We did not find differences between the weight bearing and the weight-protected patients. This means that either postoperative motion is unimportant or that all patients, irrespective of whether they were weight bearing immediately or not, experienced postoperative interface motion. We believe that cyclic strains (Shimagaki et al. 1990, Ryd et al. 1993) may well overwhelm any effect of the cooled saw blade. The bone preparation after using the cooled/standard saw blade proceeded by drilling large holes for the bosses of the prosthesis (and 2 of the screws). Thus substantial parts of the bone from the initial cuts were resected (Toksvig-Larsen et al. 1991a). This reduced the initial surface and the potential effect of the cooled saw blade, by about 25 percent.

A tight fit between bone and implant is another important factor for prosthetic fixation. In knee arthroplasty, this refers to the quality of the cut surface. The bone-cutting results in this study were far from optimal with a mean roughness of 1.7 mm and a flatness of 0.3 mm for both types of saw blade. The gap between bone and implant should preferably not exceed 0.3–0.5 mm in unloaded implants (Sandborn et al. 1987, Carlsson et al. 1988). In dogs Stulberg et al. (1991) found that good fixation with absence of movement in the interface requires at least 30 percent ingrowth of available pore volume of the peg and tibia plateau. In our study, the subsidence during the first 6 weeks introduced a mean 25 (2–51) percent of the bone to within 0.3 mm from the prosthesis. As regards the smoothness of the surfaces cut by the 2 mm thick prototype saw used in this study it has been shown to be inferior compared with the surfaces from the thinner 1 mm blade (Toksvig-Larsen et al. 1994).

Our study showed greater stiffness in the bone-prosthesis interface when using an internally cooled saw blade, and a tendency to less continuous migration, when using the PCA bossed tibia component with screw fixation. This may indicate a positive effect of the cooled saw blade on prosthetic fixation.

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