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THE RADIOLUCENT ZONE IN ARTHROPLASTY OF THE KNEE

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Roentgenograms of 138 knee joint arthroplasties were examined for the presence and extent of a radiolucent zone at the bone-cement interface. Such a zone was significantly more common around the plastic tibial part than around the metallic femoral part of non-hinged prostheses. This observation argues for the theory that the development of heat plays a part in the causation of the zone. In some cases a zone was demonstrable within 1 month of the operation. The frequency and the sizes of such zones increased during the first 6 months after the operation. There was no definite correlation between the development of a radiolucent zone and the clinical symptoms.

Key words: arthroplasty; knee joint; radiolucent zone

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The roentgenogram after total knee arthroplasty often shows a radiolucent zone at the bone-cement interface. This zone does not exceed a few millimeters in width. It has a well-defined limit and is sometimes surrounded by a more or less pronounced sclerotic zone in the bone. It should be differentiated from the wider, more diffusely limited zone, sometimes with so-called "scalloping", typical of infection. The cause and the clinical significance of this zone are unknown. It was therefore thought worthwhile to focus special attention on the problem in association with a review of total arthroplasty of the knee at the Department of Orthopaedic Surgery, Malmö General Hospital (Ahlberg & Lindén 1977).

MATERIAL AND METHODS

Roentgenograms of 138 knees treated with arthroplasty (16 Guépar, 82 Geomedic, 40 St. Georg) during the period 1972–1975 were examined for a radiolucent zone around the femoral and/or tibial part, and were classified into four groups according to the extent of the zone (Table 1, Figures 1 and 2). The roentgenograms were routine frontal and lateral views obtained at various intervals after the operation. As a rule the examinations were performed immediately after operation and 1, 3, 6 and 12 months postoperatively. The occurrence and extent of the zones were examined for any correlation with (a) the type and part of the prosthesis, (b) the interval after the operation, (c) the amount of cement and, (d) the clinical symptoms.

Table 1. Classification of zones.

0 =	No zone.
+ =	Zone occupying less than half bone-cement interface.
++ =	Zone occupying more than half, but not all of bone-cement interface.
+++ =	Zone occupying entire bone-cement interface.

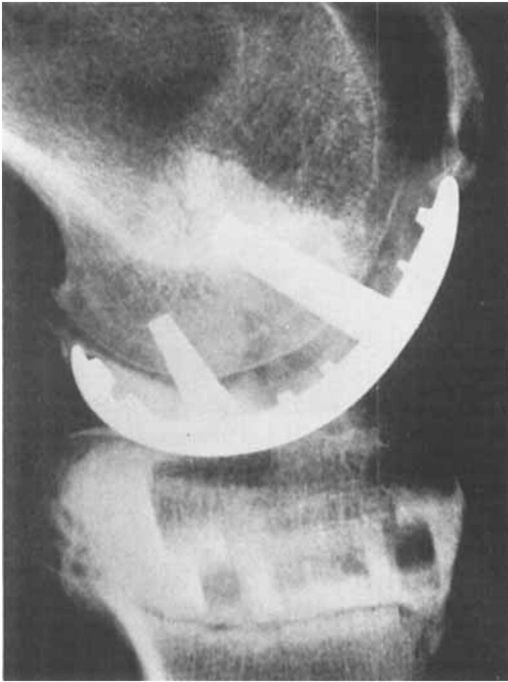

Figure 1. St. Georg arthroplasty. Radiolucent zone femur = 0, tibia = +++.

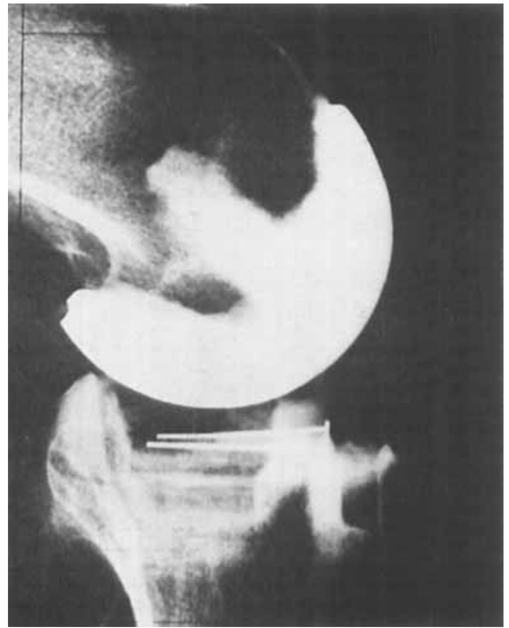

Figure 2. Geomedic arthroplasty. Radiolucent zone femur = 0, tibia = ++.

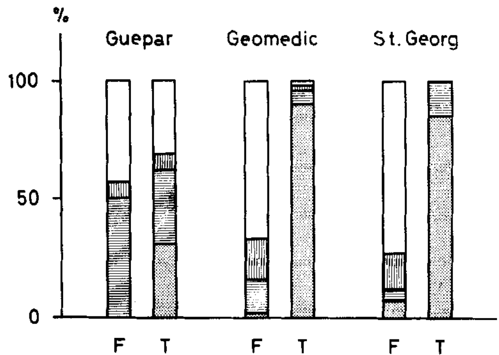

Figure 3. Radiolucent zone correlated with type and part of prostheses.

RESULTS

(a) The occurrence and extent of the radiolucent zones relative to the type and part of the prosthesis are given in Figure 3, which is based on the last roentgenogram in each case obtained 6 months to 4 years after the operation (14 Guépar, 68 Geomedic, 40 St. Georg). The number of Guépar arthroplasties was small and no significant difference was found between the femoral and the tibial parts. As for the other two types of prosthesis, radiolucent zones were almost invariably seen around the tibial part but only around one-third of the number of femoral parts. This difference is highly significant.

(b) The largest group of knees had been treated with a Geomedic prosthesis and this group was therefore used in the investigation of any variation of the incidence and extent of the radiolucent zones with the interval after the operation. It is clear from Figure 4 that within 1 month a radiolucent zone was seen in two-thirds of the tibial prostheses and in one-tenth of the femoral prostheses. The incidence and extent of the tibial zones increased rapidly from one interval to the next. The corresponding increase of the femoral ones was slow.

(c) The zones were examined for any correlation with the amount of cement in the same group as (b). The amount

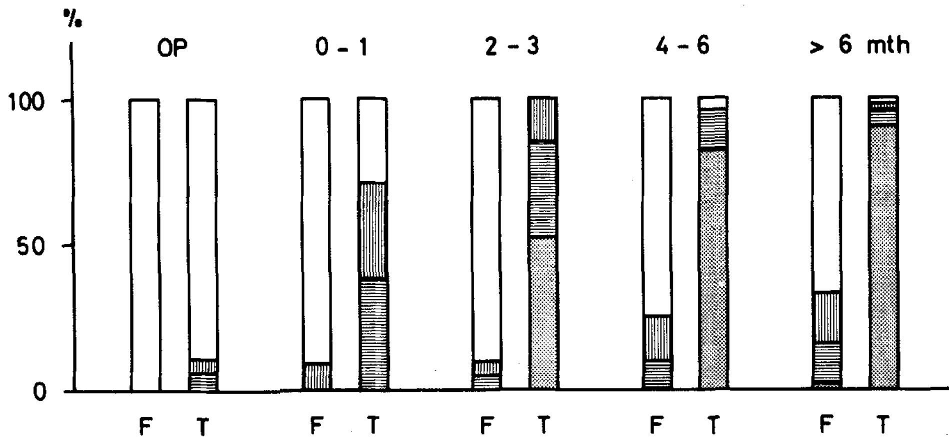

Figure 4. Radiolucent zone correlated with time after operation in Geomedic arthroplasty.

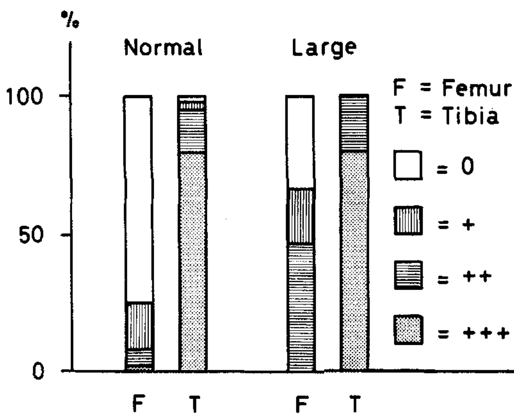

Figure 5. Radiolucent zone correlated with amount of cement in Geomedic arthroplasty.

of cement was classified as large in 15 femora and 10 tibiae owing to an unnecessarily large reaming or to communication with subchondral cysts. No difference in the incidence of tibial zones was found between the two groups, possibly because of the relatively high frequency of zones even in tibiae with a normal amount of cement. In femora with a large amount of cement, zones were twice as common as otherwise (Figure 5). The difference, however, was not significant.

(d) Of the patients who had been followed up for at least 6 months, 15 reported moderate persistent pain and six severe pain. The distribution of these cases according to the various groups of zone formation did not differ from that in the entire material.

DISCUSSION

The cause of the radiolucent zone is still obscure. Three possibilities have been discussed, viz., mechanical injury to vessels during preparation of the bed, chemical injury caused by the monomer, and thermal injury from the heat generated by polymerisation. Various model experiments favour one or the other of these theories or argue against others. Thus, Jefferiss et al. (1975) contend that the heat generated is unimportant while Feith (1975) claims that it is more important than the chemical and mechanical factors. According to Linder (1977) the surgical preparation of the bed is more important than the monomer leakage.

The most significant result of the present clinical investigation was that a radiolucent zone is the rule around the tibial but the exception around the femoral part of non-hinged prostheses. It is possible that part of the radiolucent zone around the femoral prosthesis remained concealed because the metal is projected over part of the bone-cement interface.

But those parts of the bone cement interface demonstrable in the roentgenogram are sufficient to reveal any true difference between the femur and the tibia. This can hardly be explained by mechanical and vascular damage from the preparation. In both parts the preparation of the bed is the same and the cement is placed in spongious bone. Also any toxic effect of monomers should presumably be the same since Linder (1977) has shown that the cement volume is irrelevant for the monomer loss from the cement. An important difference, however, is that the tibial prosthesis is made of high density polyethylene and the femoral prosthesis of metal. The latter conducts and takes up heat more readily and this results in the effect of the heat being smaller around the femoral part of this form of prosthesis. In hinge prostheses, however, both the femoral and the tibial parts are made of metal, and in these cases no difference in frequency of radiolucent zones was found between the two parts. The investigation therefore appears to suggest that the generation of heat plays a role in the development of the radiolucent zones.

In about one-tenth of the tibial parts of the Geomedic prostheses, a zone was present already in the immediate postoperative films. The same observation has been made by Insall et al. (1976) in their total condylar prostheses and a probable explanation is a thin film of blood between the cement and bone. Already 1 month after the operation a zone was seen in two-thirds of our Geomedic prostheses, and this number continually increased during the first 6 months after operation. The same observation was made by Reckling et al. (1977) who believed that the reason for this was a micromotion between bone and cement. The progression of the zone, however, might also be explained by thermal necrosis with subsequent bone absorption (Slooff 1971).

The appearance of a zone is sometimes regarded as a sign of loosening of the prosthesis. One reason for this may be that both the radiolucent zone and loosening most often are localized to the tibial part. In the present material there was no demonstrable correlation between postoperative results or persisting clinical symptoms and the occurrence of zones.

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