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Fracture of hip prostheses due to inadequate welding

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Twenty-five patients underwent total hip arthroplasty using a copy of a well-known prosthesis during the period 1974–1976. Five of the prostheses fractured through the neck after 5–12 years. There were no prodromal symptoms and no trauma preceded the fractures. Technical analysis revealed that inadequate welds were responsible.

Fatigue fracture of the stem of femoral components is relatively common and is usually caused by loosening of the cement and consequent lack of medial support (Wroblewski 1982). On the other hand, fracture of the neck of femoral components is rare and only a few cases (with or without loosening) have been reported in the literature (Burstein & Wright 1985). The load on the neck, in contrast to the load on the stem, cannot be increased by loosening, so the reason for neck fracture must be related to the design or constituent material of the prosthesis.

We report 5 cases of femoral component neck fracture in the absence of loosening or trauma.

Patients and methods

Five patients suffering from arthrosis had one hip replaced in a local hospital between October 1974 and February 1976. Their ages at primary operation ranged from 60 to 75 years. All of them had an uneventful postoperative course. There were no radiographic signs of loosening at the time of fracture, and there were no symptoms from the hip prior to fracture. In all 5 cases the fracture was similar, perpendicular to the axis of the neck (Figure 1). The time interval from primary operation to fracture ranged from 5 to 12 years (Table 1).

In no case was there a history of trauma prior to the fracture. All the fractures occurred when the patient was either standing or walking slowly. One of the patients, a woman of 81 years, was brushing her teeth when she suddenly felt her leg give way, but she managed to avoid falling by holding on to the lavatory basin. In all the cases, revision was performed within a few days. In no case did any of the components appear loose at revision, and in all the cases only the femoral component needed to be replaced. No complications occurred after revision.

All five prostheses were marketed by Mecron GMBH in West Berlin. In total, 25 femoral components of this type were delivered under the name "type Brunswik," to the hospital. Apart from the marking, the exterior of the femoral components could not be distinguished from the original Brunswik prosthesis, which was manufactured in a totally different way (Figure 2). The

Table 1. Data from five patients with fracture of the prosthetic neck

Case	THR year	Fracture year	Age at fracture	Sex	Activity at fracture
1	1975	1979	69	M	Standing
2	1975	1979	78	M	Walking slowly
3	1976	1982	75	F	Hanging laundry
4	1974	1986	82	F	Brushing teeth
5	1974	1986	79	M	Lifting flowerpot

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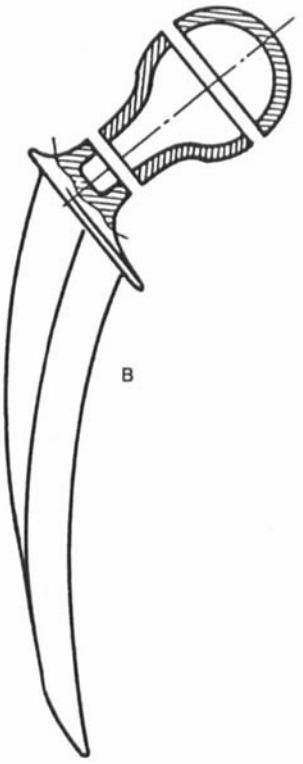

Figure 1

Figure 2

Figure 1. Fractured prosthesis.

Figure 2. A. Original Brunswik prosthesis, the head welded to the neck.
B. "Type Brunswik" prosthesis, cast parts to be welded together.

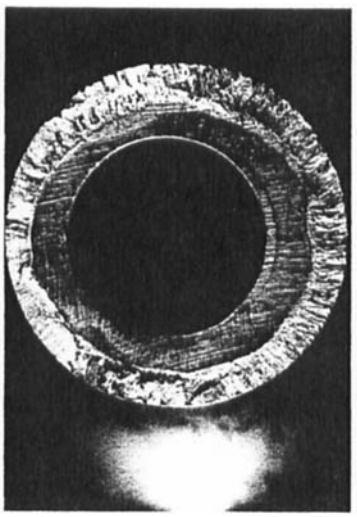

Figure 3

Figure 4

Figure 5

Figure 3. Fractured prosthesis cut along the neck. Welds appear bright at the sides of the fracture.

Figure 4. Fracture surface. The inner half of the surface has not been welded.

Figure 5. Crack and pores in the cast material, not adjacent to the fracture.

"type Brunswik" is marked "Villoy", whereas the original Brunswik is marked with the "Vitallium" symbol and a code number. According to the Swedish representative for Mecron, no other "type Brunswik" prostheses have been delivered in Sweden.

Three of the fractured prostheses were examined technically (Cases 3–5). One of them (Case 4) was cut along the axis of the neck. The surface was ground, polished, and etched (ASTM E 340–68) with Kelling's reagent (ASTM E 407–70 no. 95) in order to visualize the welds (Figure 3). The fracture surfaces of the other two prostheses were studied in a scanning electron microscope.

Results

On visual observation the cut surface along the neck revealed that the prosthesis consisted of three pieces that had been cast separately and welded together (Figure 2). Thus, there was a weld around the equator of the head and a second weld encircling the middle of the neck (the original Brunswik prosthesis has no weld in this latter, highly stressed area). Both components of the neck had hollow centers with a wall thickness of 4.2–4.4 mm. In all three examined prostheses, the fracture had occurred through this weld, and it was apparent from radiographs that the same had happened in the other two cases. This weld did only penetrate half of the wall thickness, leaving an open slit on the inside (Figures 3, 4). The cut prosthesis also showed a 4-mm crack in the fillet between the neck and the flange and a number of pores in the cast material that were not immediately adjacent to the fracture (Figure 5).

The scanning electron microscope (SEM) fractograms showed that the fracture surface of the weld had a dendritic structure in large areas (Figure 6). This dendritic structure extended to the surface of the prosthesis, whereas at the other end – in the transition zone between root gap and filler material – the fracture had developed in an intercrystalline mode. In this area, fatigue striations were seen (Figure 7). Only a small area in this transition zone displayed dimples, indicating ductile material and final rupture. Schematically, the different SEM findings were located, as in Figure 8.

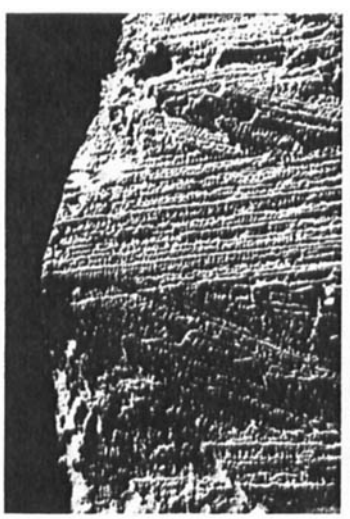

Figure 6

Figure 7

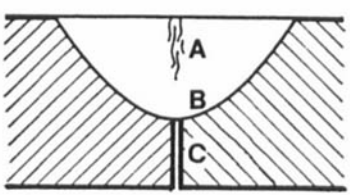

Figure 8

Figure 6. Dendritic structure of the fracture surface. Most of the fracture had this appearance. Light microscope×100.

Figure 7. Fatigue striations, found where full fusion of the weld was achieved. Width of each striation: 2,5 microns. (SEM.)

Figure 8. Schematic drawing of weld.
A. Dendritic structure at fracture surface (incomplete fusion).
B. Intercrystalline fracture with fatigue striations.
C. No fusion.

Discussion

The dendritic structure of the fracture surface indicated that the solidification zone of the weld had propagated as two fronts starting near the cast material on each side of the weld and meeting in the middle. The two fronts had pushed gas and impurities in front of them preventing metallic bonding between the meeting solidifying zones, and resulting in low mechanical strength.

The fatigue striations had developed in the small part where stress was concentrated due to the imperfection of the rest of the weld. For each cyclic load, the crack had propagated the distance between two striations until final rupture.

Thus, the fracture occurred through a weld in the neck of the prosthesis because of stress concentration and fatigue. Stress concentration was caused by lack of fusion due to inadequate welding technique and weak metallic bonding due to faulty welding parameters.

We have not been able to find a single report of similar femoral component failure in the literature. Five identical failures in 25 cases is surprising as is the inadequate manufacturing technique. The original Brunswik prosthesis was in widespread and successful use when the "type Brunswik" prostheses of this study were implanted. The two prostheses look identical and the surgeons implanting the "type Brunswik" prostheses had no reason to suspect that these prostheses were unsoundly manufactured.

We report these cases as a warning against using undocumented copies of well-known implant designs. We believe that, as in industry, a prospective manufacturer should be required to present a quality assurance program.

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