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INTERTROCHANTERIC DISPLACEMENT OSTEOTOMY

Metallic Failure Following Osteosynthesis

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Metallic failure is extremely rare in intertrochanteric displacement osteotomy. In the cases reported it has occurred in connexion with non-union, invariably in the form of plate failure (Rosborough & Stiles 1967, Scott 1967), according to Scott a secondary consequence of the non-union, i.e. a stress fracture. Rose et al. (1972), however, in a metallurgic analysis of a plate fracture in non-union, found the cause to be a combination of stress and corrosion. No data are available as to whether the screws may fail also, as in the unstable intertrochanteric fractures (Foster 1958).

It seemed appropriate, therefore, to report the frequency of metallic failure in intertrochanteric displacement osteotomies fixed by 3 different types of implants, followed up by a metallurgic examination of the metallic failure.

MATERIAL

During the 15-year period from 1957 to April 1972 a total of 496 intertrochanteric displacement osteotomies were performed in the Department of Orthopaedic Surgery, Odense University. All the osteotomies were performed by the same operative technique, but concurrently by three different fixation methods. After the operation non-weightbearing was enforced for at least 3 months, and weightbearing was not allowed until radiography revealed union.

During the 11 years from 1957 to 1968 the fixation method was by the Bosworth apparatus made of vitallium, which was applied to 125 osteotomies. These were followed by non-union in 9 cases, but there were no instances of plate failure. In one case a screw broke while being inserted.

During the 7 years from 1965 to April 1972 (and onwards) a special technique has been in use, viz. compression osteosynthesis and fixation by McLaughlin's apparatus made of vitallium. Using this method 278 osteotomies were performed. After 1970 there have been 2 cases of non-union, but not one of metallic failure.

In both groups screws of a 3.54 mm diameter were used.

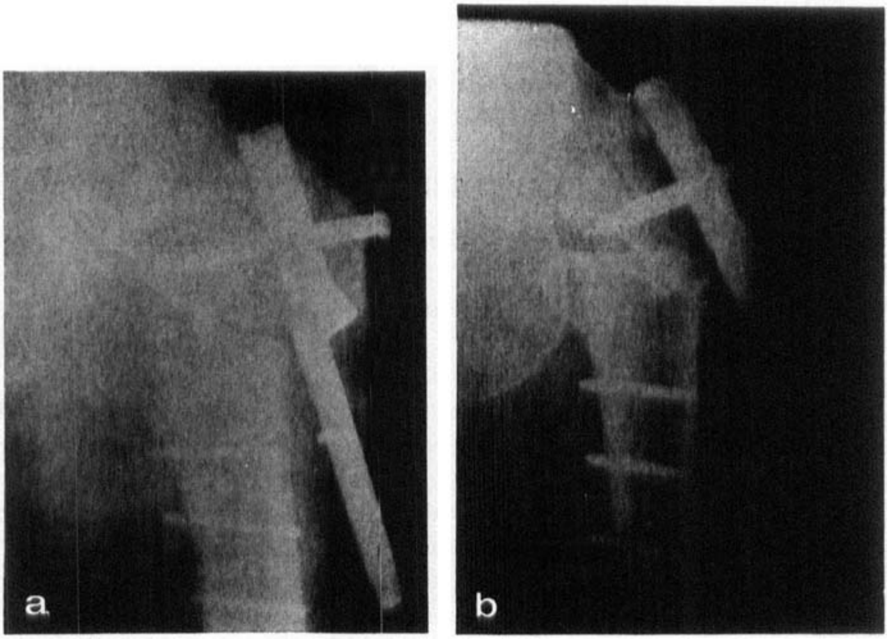

Figure 1 a, b. Total screw failure with instability at the osteotomy site a few days after the operation.

During the 4 years from 1968 to April 1972 (and onwards) a fixation and compression method—the Wainwright-Hammond apparatus—was used in a total of 93 cases. In the first 20 cases the material was titanium, and the screw diameter was 3.97 mm, viz. 0.4 mm larger than that used so far. After these first 20 cases vitallium was substituted for titanium, because in 5 out of the 20 cases the screws broke, resulting in instability at the osteotomy site. The 5 breakages occurred from two weeks to 3 months after the operation (Figures 1 a, b, 2 a, b, c). All the patients had been complaining of pain right from the time of operation, and the cause was not disclosed until radiography was performed.

Since that time 73 osteotomies have been performed using the Wainwright-Hammond apparatus made of vitallium with a diameter 3.97 mm as in the titanium apparatus. There have been no screw failures since the vitallium apparatus was introduced, and no cases of non-union have been observed.

ANALYSIS

To elucidate whether the screw failure might be due to causes other than the lesser hardness of titanium, 8 titanium screws 3.8 cm in length, 2 single-slot and 6 cross-slotted, 8 titanium screws 4.4 cm in length, 4 single-slot and 4 cross-slotted, and 2 broken titanium screws

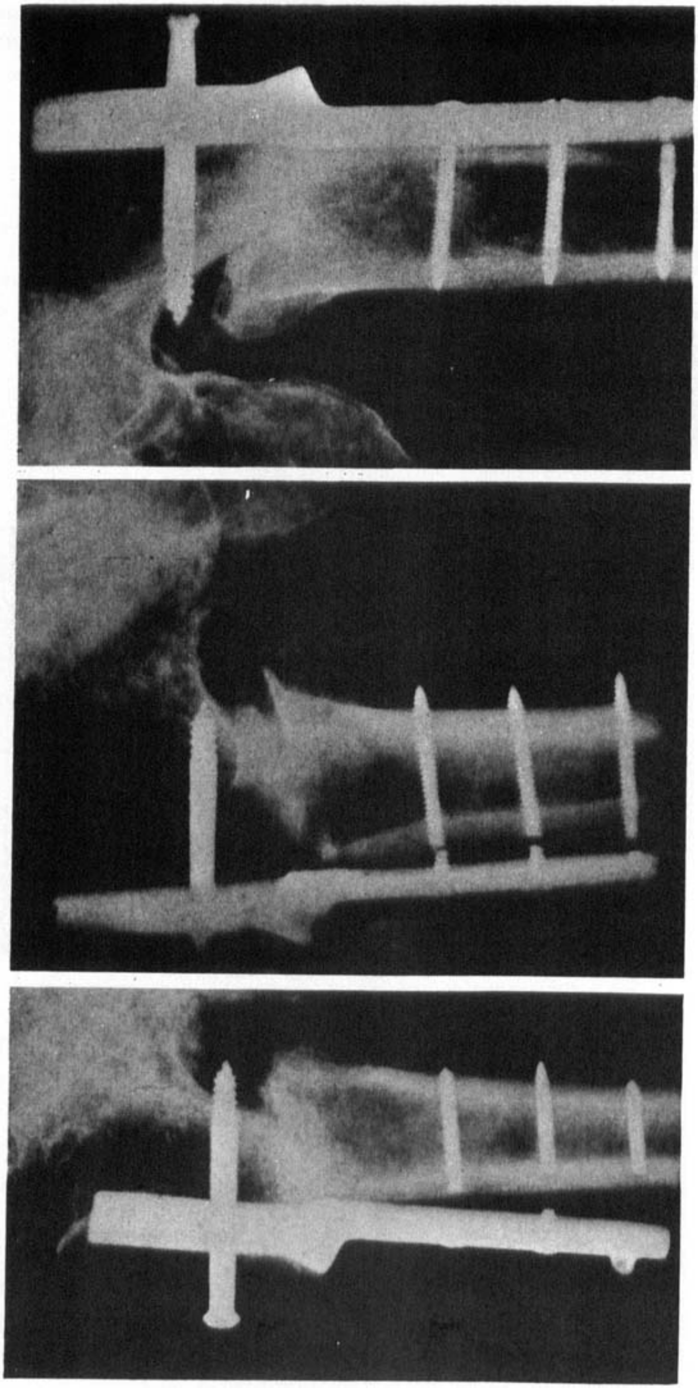

Figure 2 a, b, c. Screw failure 3 months after the operation. The osteotomies have united in a varus position.

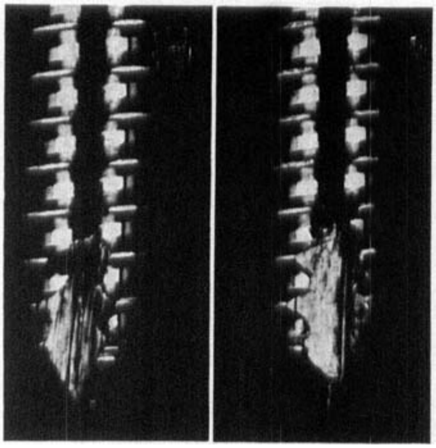

Figure 3 a. Titanium screws with sharp thread profiles and muzzy cut (× 7.5).

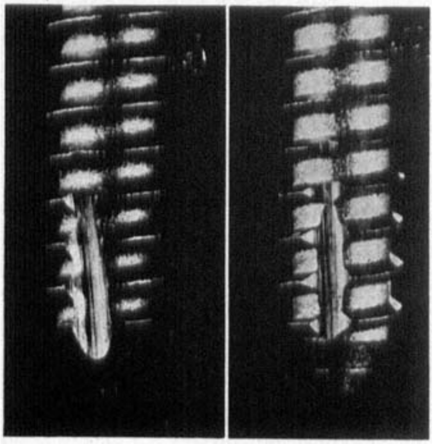

Figure 3 b. Vitallium screws with round thread profiles and sharp cut (× 7.5).

were sent for examination to the National Institute for Testing of Materials in Copenhagen. All the screws had been removed from the original packing. For comparison (Weismann 1971), 6 vitallium screws 3.8 cm in length, cross-slotted, and 6 vitallium screws 4.4 cm in length, cross-slotted, were sent as well. All the screws were of the same diameter, viz. 3.97 mm.

From the National Institute report it was apparent that on inspection there was a difference in the appearance of the self-tapping flute in the screw tips (Figure 3 a, b). The vitallium screws had a sharp, pure flute, the titanium screws a frayed, somewhat muzzy flute. The thread profile of the titanium screws had sharp transitions. Moreover, the fracture surfaces in the broken screws showed that these were not fatigue fractures, but had to be considered fragility fractures. Measurements showed a variation of 0.3 mm in diameter for the titanium screws. This variation was less than 0.1 mm for the vitallium screws. Tension was tested by supporting the screw head in a tool, and the tension was transferred to the screw tip. From Table 1 it may be seen that the tensile strength is greatest for titanium 3.8 single-slotted screws and least for titanium 3.8 cm cross-slotted screws, whereas the vitallium screw was midway between. In the metallographic investigation it was discovered that the screw having the greatest tensile strength, titanium 3.8 cm single-slot, was a chrome nickel steel screw.

Table 1. Results of tension testing by the National Institute for Testing of Materials, Copenhagen.

Sample designated:	Screw length (cm)	Tensile strength (approx. kp.)
Titanium single-slot	4.4	560
Titanium cross-slotted	4.4	445
Chrome nickel single-slot	3.8	852
Titanium cross-slotted	3.8	500
Vitallium cross-slotted	4.4	638
Vitallium cross-slotted	3.8	600

The conclusion of the National Institute was that it would serve no purpose to continue the investigation, as our store of titanium screws had to be considered inapplicable unless it was sorted. It was investigated then, whether it was the titanium screw which breaks because of its insufficient strength or whether it is the chrome nickel screw which breaks because it is too hard. According to the estimate of the National Institute, neither screw was of a satisfactory workmanship. The vitallium screws appeared to be of a more reliable make than the titanium screws.

DISCUSSION

As non-union is a presupposition for a stress fracture, it is important to obtain primary union. This depends upon several factors. The risk of non-union is increased by too marked a displacement, a steep osteotomy line, and varus osteotomy as well as weightbearing too soon (Rosborough & Stiles 1967, Scott 1967, Green 1967, Holst-Nielsen et al. 1972).

In a mixed osteotomy material of 108 osteotomies Rosborough & Stiles had 14 cases of non-union. In 6 of these cases there was plate failure, of which 3 were fixed angular plates and 3 were straight plates, whereas with a variable angular plate (McLaughlin) there were 3 cases of non-union without metallic failure. This finding was confirmed by Scott who observed fracture of a fixed angular plate in 9 out of 12 cases with non-union, but with a straight plate fracture occurred in only one patient out of 9. In the present material treated by Bosworth's and McLaughlin's apparatuses, there was no metallic failure in 11 cases of non-union, and this is in keeping with what has been reported in the literature.

In the Wainwright-Hammond group the causes of screw failure were analysed metallurgically. They proved to be not exclusively the lesser strength of titanium. Insertion of the screws was prepared by drilling with a 3.2 mm burr. There is a variation in the diameter of the titanium screws of ± 0.3 mm, the range being from 4.27 to 3.67 mm. Considering also the poor workmanship of the screws, this causes an unnecessarily hard insertion in cases where the diameter is 4.27 mm. Where the diameter is 3.67 the insertion will be looser. In all, this gives rise to a varying tension along the plate. If one screw fails, the other screws are likely to fail also. There proved to be 2 chrome nickel screws in the material both single-slotted and 3.8 cm in length. The screws had been removed from the original titanium packing, and they represented our remaining store of titanium screws. The possibility of a packing fault is most likely, as the factory from which the material had been purchased manufactured the Wainwright-Hammond apparatus in chrome nickel steel as well as in titanium. They cannot have been derived from our own store of screws, as screws of a diameter of 3.97 mm have never been bought or used in the Department.

The titanium screws used in the present material were of pure titanium. In recent years stronger materials of titanium have appeared, in the form of titanium alloys, the most important ones being known as T. 318® (a titanium, 6 per cent aluminium, 4 per cent vanadium alloy) and T. 680® (a titanium, 11 per cent tin, 2¼ per cent aluminium, 4 per cent molybdenum, 0.2 per cent silicon alloy). When heat-treated these alloys are superior to pure titanium in mechanical properties (Brettle et al. 1971).

In the 5 cases in which the implant was removed the plates were in the same state as when inserted. There was no reaction around the implants, no blackening of the tissue as described by Emneus & Gudmundsson (1967). As there were no signs of corrosion, presumably because of the short time the implant had been *in situ* (two weeks to nine months), further investigations of the plates were not carried out.

SUMMARY

496 intertrochanteric displacement osteotomies were analysed for metallic failure. The osteotomies are distributed between 3 concurrent fixation methods: 125 using Bosworth's apparatus, 278 using McLaughlin's apparatus, and 93 using Wainwright-Hammond's apparatus. No metallic failure occurred among the cases treated by Bosworth's and McLaughlin's apparatus made of vitallium. Among 20 osteotomies fixed by Wainwright-Hammond's apparatus of titanium, screw failure occurred in 5 cases. In all 5 cases this resulted in instability of the osteotomy. Two patients required re-osteosynthesis, whereas in 3 cases it proved sufficient to remove the implant, as the osteotomy had united. The screw failures were analysed at the National Institute for Testing of Materials in Copenhagen where the cause was found to be poor workmanship of the screws.

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