BONE STRUCTURE AFTER REMOVAL OF INTERNAL FIXATION PLATES

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We used single-photon absorptiometry to assess the forearm bones after the removal of internal fixation plates in 14 patients. We found convincing evidence of cortical atrophy in only one patient, in whom the plates had been removed prematurely after only 16 months.

It is suggested that such plates should be retained for at least 21 months, to allow bone density to return to its prefraction level. The recommendations of the AO/ASIF group are supported.

It is well established that the removal of an internal fixation plate leaves behind a weakened bone and is associated with a significant incidence of refracture (Uhthoff and Dubuc 1971; Akeson et al 1976; Tonino et al 1976; Moyen et al 1978; Stromberg and Dalen 1978; Terjesen and Benum 1983; Harkess, Ramsey and Ahmadi 1984). In animal studies, interest has been focused on the atrophic changes seen in the bone as a source of weakness after plate removal. These changes have been variously attributed to the mechanical effects of rigid plates causing stress protection (Uhthoff and Dubuc 1971; Paavolainen et al 1978; Slätis et al 1978; Terjesen and Benum 1983) and to vascular disturbance at the time of plate application (Gunst 1980; Jacobs, Rahn and Perren 1981; Perren et al 1988). The degree of cortical atrophy seen in animal studies has not been confirmed in man, but studies have been confined to the tibia, although the incidence of refracture after plate removal is highest in the forearm (Harkess et al 1984; Hidaka and Gustilo 1984; DeLuca, Ruwe and Lindsey 1987).

We aimed to assess the state of the forearm bones after the removal of internal fixation plates.

PATIENTS AND METHODS

All patients that were routinely admitted for plate removal were scanned on a single-photon absorptiometry system. The system used was a Nuclear Data model ND 1100A bone mineral analyser incorporating an iodine-125 radioactive source. The forearm to be scanned was immersed in water to normalise for variability in soft-tissue thickness. The water bath was constructed to allow accurate repositioning of the forearm.

About one week after plate removal the wounds were inspected and, if healing was satisfactory, a single-photon absorptiometry scan was performed on the operated forearm and on the non-operated arm as a control. With the forearm correctly positioned, the system performed a 'proximal scan' consisting of six traverses of the forearm at 4 mm intervals moving proximally from a predetermined position.

Data were presented as total bone mass corrected for fat (BM) and bone mass corrected for fat per unit bone width (BM/BW). The graphical presentation of each scan provided an image comparable to that produced by optical densitometry (Inoue et al 1983) allowing the estimation of bone dimensions, in particular of cortical width. In accordance with accepted practice, BM was measured as an indicator of total bone mass and BM/BW as an indicator of bone density. Coefficients of variation were calculated for repeat measurements performed on the same patients.

Sources of error. Repeat scans were performed on the non-operated forearms of two patients. The first was measured four times and the second three times. These measurements yielded coefficients of variation of 1.6% and 1.0% for BM, 1.6% and 0.7% for BM/BW and 1.1% and 2.1% for mean cortical width respectively. This degree of reproducibility was consistent with previous...
studies (Cameron, Mazess and Sorensen 1968; Poll, Cooper and Cawley 1986). Preliminary studies on both arms of normal subjects supported the use of the contralateral limb as control in these measurements at diaphyseal bone. No allowance was made for the reduced bone mass in the operated limb caused by the presence of screw holes.

RESULTS

We studied 14 patients, none being excluded for problems of wound healing. Details of them are shown in Table I, where the results from the operated limb are given as percentages of the control limb values. Bone mass (BM) was 87.1% to 147.3% of the control limb (mean 107.1%), bone density (BM/BW) was 89.9% to 114.7% (mean 101.9%) and mean cortical width in 12 patients was 83.9% to 140.0% (mean 107.6%). In two patients callus at the fracture site made measurement of cortical width impossible.

In only one patient were all three parameters significantly less than those in the control limb (bone mass 87.1%, bone density 89.9%, cortical width 83.9%). In this patient the time from fixation to removal was only 16 months; a further scan performed six weeks after plate removal showed full recovery (bone mass 106.5%, bone density 103.4%, cortical width 100.0%).

In Figure 1 bone density is plotted against the interval between internal fixation and plate removal, excluding the two patients with significant callus formation because this mode of fracture healing was not typical of that seen under rigid plates. It has been recommended that plates be removed from the forearm between 18 and

![Graph showing bone density related to the interval between internal fixation and plate removal in 12 patients.]

**Table I.** Details and results from 14 patients after removal of forearm plates

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Sex</th>
<th>Dominant side</th>
<th>Bone</th>
<th>Plate</th>
<th>Delay Fixation to removal (mth)</th>
<th>Removal to scan (days)</th>
<th>Bone structure (% of other side)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Mass</td>
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<td>17</td>
<td>M</td>
<td>D</td>
<td>Radius</td>
<td>DCP</td>
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<td>5</td>
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<td>48</td>
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* DCP, dynamic compression plate  † D dominant side, N other  ‡ healed with callus formation
24 months after internal fixation (Müller et al 1979). Taking 21 months as the mean recommended interval, Figure 1 shows that, of those without callus formation, six patients had plates removed before and six after this time. Four of the six with early removal had a bone density of less than the control limb, but only one of six in whom the plates had remained for more than 21 months.

DISCUSSION

Bone strength after plate removal does not relate solely to bone structure: residual screw holes are an additional important source of weakness (Hidaka and Gustilo 1984). Nevertheless, atrophic changes have been widely accepted as an adverse effect of rigid plates. Such changes have been reported in animal studies, but whether they persist until the plate is removed has been disputed. Most studies have concluded that they do persist until the plate is removed, and this has led to the recommendation that plates should be removed as soon as possible after fracture union (Uthoff and Dubuc 1971; Akeson et al 1976; Moyen et al 1978; Stromberg and Dalen 1978; Terjesen and Benum 1983; Uthoff and Finnegan 1983). In contrast to this view, Perren and Rahn (1980) have suggested that osteoporosis is a transient phenomenon after plate fixation, shown to resolve within one year in sheep even when the plate remains in position.

In our study, we did not correct for the effect of screw holes, so we may have underestimated the true mass and density of the bone in the operated forearm. Despite this, we found convincing evidence of cortical atrophy in only one patient, in whom the plates had been removed after only 16 months. Reduced bone density was more common in patients whose plates had been removed less than 21 months after fixation. These observations suggest that atrophic changes may occur after plate fixation in the human forearm, but will resolve if the plate remains in position for a sufficient length of time. We found no suggestion that bone structure deteriorated as a result of the prolonged retention of a plate.

The mean interval between plate removal and bone assessment was eight days, so we would not have detected any cortical atrophy which resolved during that period. Normally there is little active use of the limb during the first week after plate removal, so change in this period is of little practical relevance.

Studies of the human tibia after plate removal have failed to demonstrate significant cortical atrophy (Cordey et al 1985; Terjesen, Nordby and Arnulf 1986), and our results suggest that the forearm bones are similarly unaffected in the long term. We have considered only three parameters of bone structure, and have shed no light on the microstructure of bone under these conditions. However, our results suggest that bone atrophy does not contribute to refraction, provided that plates are not removed prematurely. The recommendations of the AO/ASIF group in this respect are fully supported.

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REFERENCES


