

Morbidity in the forearm flap donor arm

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Summary—A retrospective study was carried out of the morbidity in the donor limb following use of the radial forearm flap in 27 patients. Of the 13 patients whose flaps contained bone, 4 sustained fractures of the radius. This was associated with a 50% loss of power of grip and pinch, and limitation of other movements, particularly pronation and supination. In the other patients little or no loss of power or range of movement was seen. No patient had cold intolerance; a few had areas of sensory loss, related to the radial nerve. Of the 12 patients whose radial arteries were reconstructed, 7 remained patent; no patient had any clinical features of ischaemia. These findings and their implications are discussed.

The Chinese or radial forearm flap, first described by the Chinese (Yang *et al.*, 1981) is useful both as a free or as a pedicle flap. Some disquiet has been voiced about the possible deleterious effect on the hand of the removal of the radial artery, and one such case has been reported (Jones and O'Brien, 1985). The cosmetic appearance of the donor site has also given rise to some concern (Fenton and Roberts, 1985). A report on the complications arising from the use of this flap in 15 patients at two centres has been published (Timmons *et al.*, 1986). In this article we report a study of morbidity in the donor arm following the use of the forearm flap in 27 patients at this hospital.

Patients and Methods

In the 3-year period from August 1982 to August 1985 radial forearm flaps have been used on 35 patients in this unit. Four patients died and two moved away from the area. A further two declined to attend for review, leaving 27 patients who form the basis of this study. Two of these patients were too ill to be evaluated fully.

The age distribution of the patients is shown in Table 1. The youngest patient was 11 years old and

the oldest 80. The average age was 52 years. The sex ratio of 18 males to 9 females reflects the situations in which the flap was used (mainly intraoral tumours and limb trauma). All 27 patients were right hand dominant.

The review was carried out at varying times following flap transfer, ranging from 2 to 36 months; all but three were at least 9 months postoperative at the time of review.

The flaps comprised 2 pedicle and 25 free flaps, of which 20 were used for intraoral reconstruction (Table 2). Of these 20, 13 incorporated a segment of the radius for mandibular reconstruction. Two flaps were from the dominant arm (one free and one pedicle) and the others from the left, non-dominant arm. The sizes of the skin paddles varied from 6 × 5 cm to 19 × 15 cm.

At review, the patient was asked for any comments, problems or concerns that they had concerning their donor limb, and specifically asked about cold intolerance. Examination included the size and position of the donor defect, the range of movement of elbow, forearm, wrist, fingers and thumb, power of grip and pinch (measured quanti-

Table 1 Age distribution of patients in study

Age group	Number of patients
< 40 yrs	8
41-60 yrs	9
61-80 yrs	10

Table 2 Types of flap used and recipient sites

Type	Including bone?	Recipient site	Number of cases
Free	Yes	Mouth	13
Free	No	Mouth	7
		Foot	2
		Other arm	3
Pedicle	No	Same arm	2

tatively using dynamometers) and of other movements (measured on the Oxford scale).

Thumb temperature was measured using thermocouples applied to the skin of both thumb pulps, and an Allen test was carried out to test patency of vein grafts used for radial artery reconstruction. A simple clinical assessment of circulation in the hand was carried out by exsanguinating the limbs and comparing the time taken for the thumb pulps to fill with blood following release of the tourniquet.

Areas of sensory loss and any neuromas were noted, together with the appearance of the donor site in general. Radiographs were taken of the forearm in cases where bone had been removed. From the postoperative radiograph, the length of bone removed was measured, and an approximation of the cross-sectional area removed calculated.

Results

Of the 13 patients in which bone was included in the flap, four sustained fractures of the radius. The details of these patients are given in Table 3. All fractures occurred within 6 weeks of operation. In two cases, an episode of trauma which was probably responsible for the fracture could be identified; one of these two had not had the forearm protected postoperatively. The other two fractures were asymptomatic and were diagnosed radiographically. Three cases proceeded to unite, while one developed a chronic non-union with deformity.

The relationship between patient age and fracture rate is shown in Table 4. These figures suggest a higher fracture rate with age but the numbers are too small for statistical analysis.

For 11 of the 13 patients with flaps containing bone an X-ray allowed measurement of length and cross-sectional area of bone removed. There was no

Table 3 Details of patients with fractures, and the outcome. The site refers to the length of radius removed, not to the whole bone

Age	Sex	Time	Site	Outcome	Comments
79	F	<2/52	distal	Non-union	Old Colles fracture
80	F	<2/52	1/3	Union	No protection Episode of trauma
63	M	<6/52	1/3	Union	No trauma
42	M	<6/52	proximal	Union	Episode of trauma

Table 4 Relationship between age and fracture occurrence in this series

Age	No.	Fracture
<40	2	0 (0%)
41-60	4	1 (25%)
61-80	7	3 (43%)
Total	13	4 (31%)

difference in either parameter between the fracture and non-fracture groups (Table 5).

No patient showed any loss of range of movement at the elbow. The numbers of patients with loss of range at other joints is shown in Table 6. Except in cases of fracture, there was only the occasional patient with stiffness of the wrist and other movements were unaffected. If a fracture occurred then limitation was more likely to be found and to affect a greater number of joints.

In Table 7, the power of the hand movements are summarised. As with range of movement the patients with fractures fared worst, having an average 50% weakness of grip and pinch as compared with the unoperated limb. The non-

Table 5 Relationship of fracture occurrence to mean length and cross-sectional area of bone removal

	Length	Area
No fracture (7 patients)	92 mm	32%
Fracture (4 patients)	83 mm	34%

Table 6 Limitation of movement. The figures given are the number of patients with restricted movement and the number who could be tested

Movement tested	No bone removed	Bone removed	
		No fracture	Fracture
Forearm	0/14	0/7	3/4
Wrist	1/14	1/7	2/4
Fingers	0/14	0/7	1/4
Thumb	0/12	0/7	2/4

Table 7 Power of pinch and hook grip, expressed as a percentage of the opposite limb

Movement tested	No bone removed	Bone removed	
		No fracture	Fracture
Pinch strength	94%	86%	54%
Grip strength	99%	84%	50%

fracture patients with bone removed had a slight weakness. The patients with flaps not including bone had normal power.

The radial artery was reconstructed in 12 of the 25 free flaps, using either the cephalic or long saphenous vein. Seven grafts (59%) were patent at follow-up, as determined by the Allen test.

No clinical vascular problems were identified in the hand, whether or not the artery was reconstructed. In all patients the two thumb pulps had the same temperature and the refill time following exsanguination was also the same on both sides.

Apart from one patient who developed a troublesome neuroma of the radial nerve, no patient admitted having any sensory disturbance or cold intolerance around the donor site. Testing for sensation revealed numbness in the cutaneous forearm nerve distribution in only one patient of the 27.

However, five of the seven patients whose skin paddle extended to the dorsal surface of the forearm had an area of sensory loss in the radial territory. Two of these patients developed neuromas on the radial nerve, one requiring surgery.

No patient complained about the appearance of their donor arm, although one at least (the woman with the chronic non-union illustrated in Figure 1) had a significant deformity. Objectively, the appearance was worse if the flap extended on to the dorsal surface of the forearm or if bone had been included.

Discussion

The major morbidity seen in this series of patients was limitation of power and range of movement in patients who sustained a fracture following removal of a segment of the radius. Patients who had bone

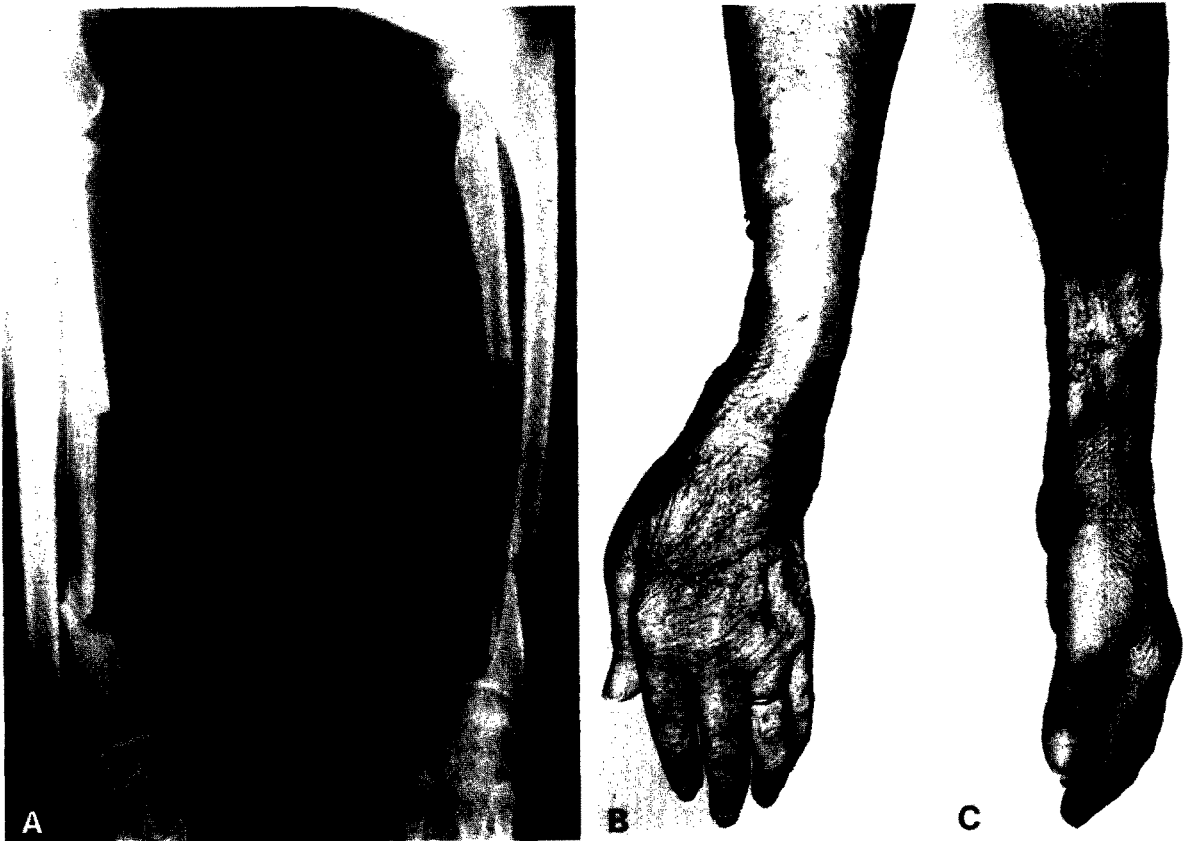


Fig. 1

Figure 1—The worst donor site (in a 79-year-old woman). (A) Radiograph at 6 weeks following operation, showing a fracture at the distal end of the removed segment (this failed to unite, despite the callus formation). (B) Dorsal and (C) lateral views of her forearm at the same time, showing a considerable deformity.

removed but did not subsequently fracture had only a mild reduction in power and no significant restriction of range, and those in whom bone was not removed were essentially unaffected. Bone removal involves removal of part of the flexor pollicis longus muscle, disruption of part of the flexor muscles' blood supply, and more prolonged immobilisation. Despite these factors it appears that if fractures can be avoided, movement in the donor limb will be little affected. Some of the factors which might predispose to fractures are:

(i) *Amount of bone removed.* We were unable to show any relationship between the length or cross-sectional area of bone removed and the chances of fracturing. Timmons *et al.* (1986) in their discussion point out that, while removing a greater amount of bone causes further weakening, the greatest loss of strength in a tubular structure such as the radius results merely from splitting the tube along its axis. We would, however, advise caution in making the bone cuts to ensure that they are not made too deep, which will cause further weakening without increasing the usable amount of bone available.

(ii) *Age.* The figures in our series (Table 4), although small, suggest a trend to a higher fracture rate with age. This would not be surprising as the elderly are known to sustain fractures following lesser degrees of trauma, and their bones are more likely to be osteoporotic. By contrast, in the young the radius can remodel rapidly, restoring the intact tube structure and with it the resistance to fracturing.

(iii) *Inadequate immobilisation.* The only patient in this series who had bone removed and whose forearm was not immobilised sustained a fracture. Following this experience all patients were immobilised for 6 weeks, usually in plaster. As all our fractures occurred within 6 weeks and as this is the standard length of time for immobilisation of forearm fractures, it seems to be a reasonable length of time to maintain immobilisation where bone has been taken. To control pronation and supination, immobilisation of the elbow joint is mandatory. This immobilisation regime has produced no significant elbow problems in this series.

Three of the fractures in this series occurred in immobilised arms. The need to inspect the skin grafted wound may have resulted in a compromise in the strength of the splints. External fixation of the radius, which has been suggested by Soutar (1985, personal communication), would solve this problem.

(iv) *Ischaemia.* By the nature of the operation, in trying to remove a vascularised segment of bone, the blood supply to the remaining radius may be compromised. This might both delay healing and predispose to fracture, and could be expected to be more of a problem in the elderly. In one of our patients, who is terminally ill from her disease and has severe generalised osteoporosis, the radiodensity of the remaining strut of radius with absence of remodelling suggests that the segment is ischaemic.

These are all factors which may have contributed towards the fractures in these patients. It is not possible, in so small a series, to be more definite as to which are most important. If fractures cannot be avoided in all cases, perhaps their management can be improved to reduce disability. All four of our patients were treated conservatively with plaster of Paris for 6 weeks; one failed to unite and three were left with limitation of forearm movement. Fractures of the shaft of the radius are subject to rotational forces from muscle imbalance, and are difficult to reduce and hold in plaster. The bony deformity following a fracture in one patient is illustrated in Figure 2. External fixation, as favoured by Soutar (1985), should enable a better position to be held and might thereby improve the eventual outcome.

It is of interest that one of the four fractures was diagnosed only as a result of this study, although in retrospect a hairline fracture could be seen on a previous X-ray. If a patient is slow to recover range or power of movement, the possibility of an undiagnosed fracture should be considered.

Vascular sequelae

It has been reported that isolated arterial injuries in the forearm produce modest but consistent alterations in circulation to the hand (Gelberman *et al.*, 1979), and that elevation of a forearm flap can produce acute ischaemia of the hand (Jones and O'Brien, 1985). In no patient in this series were there clinical signs of ischaemia, either when elevating the flap or at review. Gelberman *et al.* similarly found no clinical ischaemia in their review.

Twelve of the radial arteries were reconstructed with a vein graft (the cephalic vein if possible). Reconstruction was carried out if there was someone able to do it without prolonging the operation. The patency rate of 59% for our reconstruction is similar to that obtained by Gelberman *et al.* (1982). Of their 14 cases of isolated radial artery injury, some sutured directly and some which needed vein

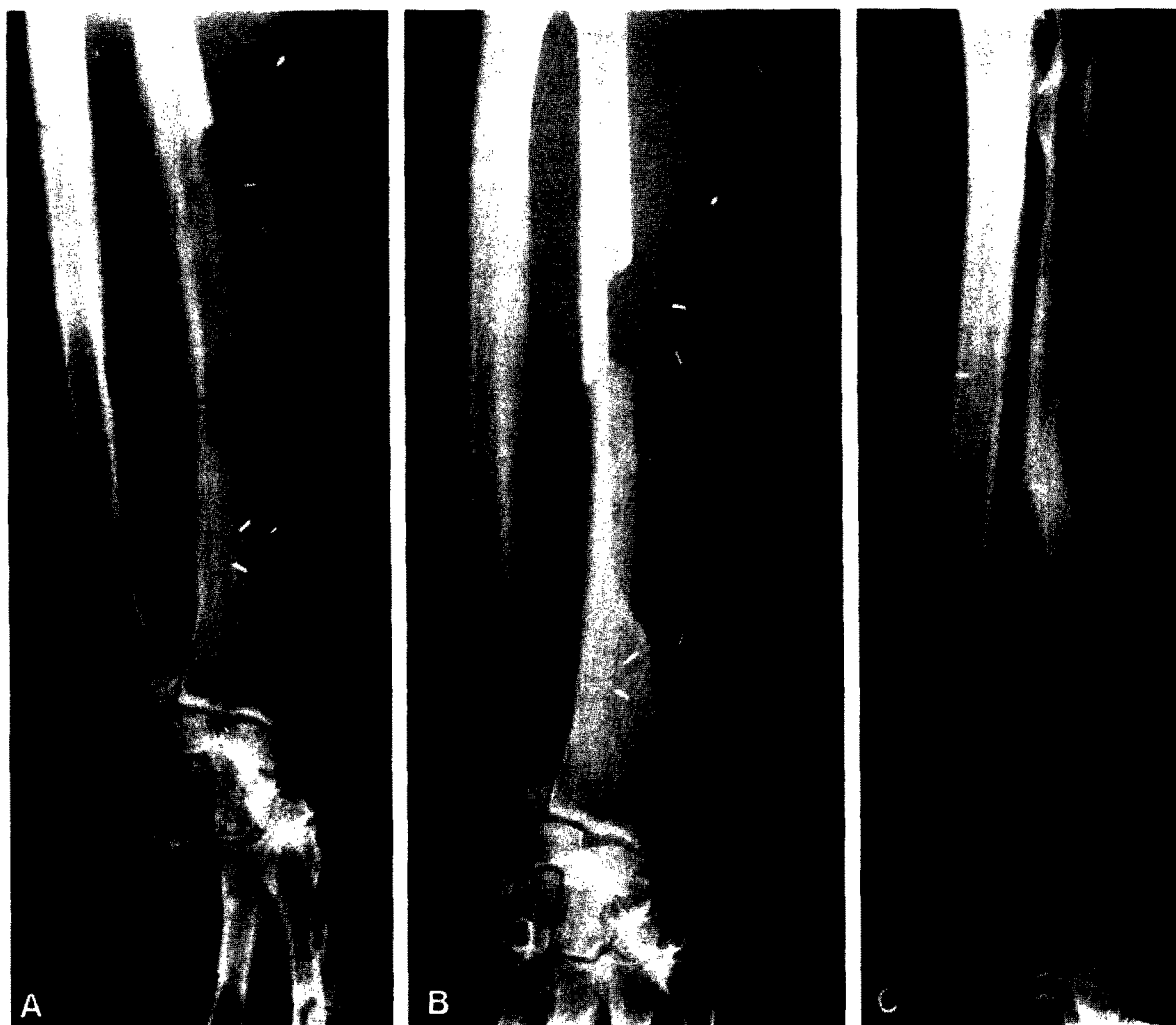


Fig. 2

Figure 2—Radiographs of the forearm of a patient with a fracture. (A) Immediately postoperatively, prior to fracture. (B) At the time of fracture. (C) Over 2 years later, the bone is soundly united but a degree of deformity can be seen.

grafts, 9 (64%) were patent at follow-up of 6 to 52 months.

In this study, no clinical advantage resulted either from reconstruction of the artery or its subsequent patency. It is hard to justify reconstruction of the artery if to do so would prolong the operation or add extra scars.

Sensory problems and cold intolerance

No patient admitted to any cold intolerance or loss of sensation in the donor hand or forearm. Timmons *et al.* (1986) found cold intolerance in 4 of their 15

cases and suggested that testosterone therapy may have played a part. None of our patients was on testosterone therapy. Many of our patients did, however, experience cold intolerance elsewhere, either in the neck following a radical neck dissection or in the opposite limb following trauma. The fact that our patients had less sensory loss around the donor site, and therefore presumably less nerve damage, may explain the discrepancy in cold intolerance findings. This, plus the increased frequency of sensory loss when the skin paddle crosses the radial nerve, suggests that where

possible the skin paddle should be taken from the volar surface of the forearm avoiding the radial nerve.

Conclusions

Flaps containing skin alone produce few complications. Inclusion of bone in the flap leads to a greater contour defect and the risk of fracture. The incidence of fracture in this series was 30% and was associated with deformity and limitation of range and power of movement. To minimise the risk of fracture, bone cuts must be made with care and the arm immobilised for 6 weeks. Fractures may occur silently, without an apparent episode of trauma, and should be suspected if a patient's movements are slow to recover. When fractures occur, some form of fixation may help to reduce the problems encountered in our patients.

No clinically apparent vascular problems arose. Although 60% of reconstructed arteries were patent at follow up, no benefit to the patient could be found from reconstruction. Sensory disturbances were usually related to the radial nerve, were rarely troublesome and can be minimised by placing the skin paddle away from the nerve on the volar aspect.

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