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Tibial tubercle elevation with bone grafts

A comparative study of autograft and allograft

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Abstract We retrospectively investigated the fate of bone auto- and allografts in 64 patients who underwent a tibial tubercle elevation with bone graft. Half of them received an autograft and the other half, an allograft that had been processed and freeze-dried. The two groups had similar preoperative characteristics concerning age, sex and pathology. Roentgenograms were reviewed by three independent observers and scored for fusion, resorption and collapse. Clinical charts were analysed for different variables. The overall radiological score for both groups did not differ statistically. Comparison of graft fixation with one or two screws demonstrated more bone resorption in the case of a single-screw fixation. In such a case, the occurrence of a preoperative tubercle fracture had a significant adverse influence, due to a less stable fixation. From the clinical charts review, only the mean stay at hospital was significantly shorter when an allograft was performed. A bone allograft appears to be suitable to maintain an osteotomy but requires a more careful surgical technique fixation to obtain a similar result to an autograft.

Introduction

Bone allografts, when available, are very attractive as a ready-for-use material coming in various sizes and shapes and for the ease of their use. Moreover, when the bone is freeze-dried, it can be stored at room temperature and is very easy to handle [16]. Unfortunately, assessment of the value of bone allografts remains rather difficult because direct comparison with autografts in the same surgical site is not possible in most cases and because the radiological aspects of the allografts are often difficult to evaluate due to their small volume or to the presence of hardware or cement [1, 2, 5, 9, 11, 20].

The advancement of the anterior tibial tubercle (Maquet's procedure) for patellar chondropathy has been advocated for several years and is usually performed with a bone graft intercalated in the osteotomy [17]. At our institution, the bone graft used for advancement was either an autogenous one from the iliac crest or a freeze-dried allograft that had been prepared in our bone bank. Because a bone graft in this procedure is clearly apparent on a lateral radiograph, this investigation was aimed at assessing the fate of bone auto- and allografts used in this elective surgery. The clinical validity of Maquet's procedure and the final results will not be discussed.

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Materials and methods

Bone graft processing

Autogenous graft was harvested from the iliac crest. Processed bone allografts were supplied by the local bone bank. The bone banking methodology has been reported previously [6]. In brief, the distal end of the femur and the proximal part of the tibia were procured in an unsterile manner from selected donors and were cut into standard shapes and sizes. They were washed thoroughly to eliminate bone marrow and blood cells. Lipids were further extracted with a chloroform-methanol solution renewed three times for at least 2 days. After being rinsed, the implants were freeze-dried and packed before being gamma-irradiated at a dose of 25 kGy (Fig. 1).

Patient data

Ninety-three consecutive cases of advancement of the anterior tibial tuberosity according to Maquet were retrospectively reviewed. All the patients were operated on in our institution by different surgeons from 1980 to 1989. Eleven tubercle elevations performed without any graft were excluded. The remaining 43 autografted and 39 allografted patients were submitted to admission criteria (Table 1). To enter the study, the involved knee should not have been the site of any bone grafting or surgical procedures. Patients should have received only one type of graft. No concomitant or ad-

Fig. 1 Freeze-dried bone allograft that is ready for use after packaging and sterilization

Table 1 Advancement of the anterior tibial tubercle performed in our institution (Magnet's procedure): admission criteria for comparison between autografts and allografts (n = 117)

	Autografts	Allografts (freeze-dried)	No graft
Total	67	39	11
Fulfilling admission criteria	32	32	0

ditional surgery should have been performed on the knee, except the release of the lateral and medial patellar retinacula. Posteropative radiographic follow-up must be available for at least a 6-month period. Patients whose data failed to fulfill these criteria were excluded from the study. Accordingly, 32 autografted and 32 allografted patients were evaluated.

Data analysis

Data about age, sex and weight at the time of surgery were collected for each patient. Statistical analysis of preoperative characteristics of both groups did not show any difference. Women made up 71% of the autografted patients and 76% of the allografted recipients. Mean age was 44 years (range 17–66) in the autografted group and 40 (range 19–66) in the allografted one. Mean weight of autografted patients was 71 ± 20 kg and of allografted patients, 79 ± 25 kg. No statistical difference was found between the groups for these criteria (Table 2).

The radiological evolution of the grafts was evaluated and scored after a 6-month follow-up on a lateral view by three indepedent observers. A scoring system was set up to evaluate fusion to the host bone, graft resorption and loss of elevation (Table 3). The evaluation of the graft fusion to the host was based on the persistence of the line of both anastomotic sites with the host bone (bone graft interface with the tibial cortex and the tibial metaphysis): disappearance (2 points), partial disappearance (1 point), persistence of a free interface (no point). Similarly, the loss of elevation was subdivided into three ratings: maintenance of the elevation (2 points), loss of between 10% and 30% of the initial height (1 point), collapse of the elevation or loss of over 30% of the advancement (0 point)

Table 2 Preoperative characteristics of autografted and allografted patients

	Autografts (n = 32)	Allografts (n = 32)
Sex (% women)	71%	76%
Age (years)	44 (17 to 66)	40 (19 to 66)
Weight (leg)	71 (51 to 90)	79 (53 to 107

Table 3 Radiological scoring system for graft evaluation

	Score	Description
Fusion	0	*Junction line not healed
		*Junction visible
	1	*Junction partially visible
	2	*Junction no longer visible
Resorption	0	*Resorption of over 50% of the initial graft volume
	1	*Resorption between 25% and 50% of the initial graft volume
	2	*Local resorption, less than 25% of the graft volume
	3	*No graft resorption
Loss of elevation	0	*Collapse of the elevation
		*Loss of over 30% of the elevation
	1	*Loss of between 10% and 30% of the elevation
	2	*No loss of elevation

Fig. 2 Significant collapse of advancement performed with an allograft and fixed with one screw

(Fig. 2). Graft resorption score was assessed by comparison with the initial graft volume. Resorption was rated with four possible scores: no graft resorption (3 points), minor signs of local resorption (2 points), resorption of more than 25% of the graft volume (1 point) or over 50% of the initial volume (0 point). Occurrence of peroperative tibial tubercle fracture was also noted.

During the postoperative period, the first day of getting out of bed, use of analgesics for postoperative pain as well as the volume of transfused blood received were recorded. Duration of hospital stay after surgery was also registered. Patient opinion was noted on a satisfaction index: very satisfied (3 points), satisfied (2 points), unsatisfied (1 point) and very unsatisfied (0 point). Patient residual pain was evaluated at the last clinical examination. Postoperative clinical data and radiological scores were statistically evaluated by non-parametric Wilcoxon's test.

Results

Forty-four per cent of the patients in both groups reached a score of 7 point, which is rated as excellent with the roentgenographic scoring system (Fig. 3). Of the patients with an autograft 43% had a good result (an overall score of 5 or 6 points) and 31% of those receiving an allograft. An overall result of less than 5 points was observed in 13% of patients with an autograft and in 25% of those with an allograft. No difference either in the overall rating or for each single critiera could be found between the two types of grafts (Table 4). The only variable that had an adverse influence on both types of graft was the mode of graft fixation. Comparison of graft fixation with one or two screws demonstrated more bone resorption in the case of a single-screw fixation ($P < 0.03$), while fusion and height maintenance were not significantly different (Table 4; Fig. 4). Comparison of allografts and autografts fixed with two screws confirms the absence of any difference between the groups (Table 5). When fixed with one screw, allografts did not differ from autografts except that a significantly higher rate of peroperative tubercle fracture was observed ($P < 0.04$). Peroperative tibial tubercle fractures occurred in 10 of the allografted patients (7 with one-screw fixation) and in 5 of the autografted patients. A one-screw-fixed allograft with a peroperative tibial cortex fracture was associated with a significantly lower radiological score than an allograft without fracture (data not shown). The latter had a score similar to that of an autograft whatever the mode of fixation (Table 5). No revision was performed due to graft failure in this series, even though one allograft collapsed completely (Fig. 2).

Fig. 3 Excellent result for this tibial tubercle advancement with a freeze-dried allograft 11 months after surgery

Table 4 Radiological score for fusion, resorption and loss of elevation obtained with allograft and autograft. Score obtained by both auto- and allografts in one- and two-screw fixation

	Score	Mean	SD	Mean	SD	Difference (%)	*P* value
Grafts		Allografts ($n = 32$)		Autografts ($n = 32$)			
Fusion	2	1.41	0.67	1.47	0.57	4.29	0.57
Resorption	3	2.47	0.88	2.75	0.57	10.22	0.13
Elevation	2	1.72	0.52	1.94	0.25	11.30	0.06
Total	7	5.59	1.76	6.16	1.02	9.13	0.24
Fixation							
No screw		3	0.10	3	0.10		
1 screw		19	0.59	8	0.25		
2 screws		10	0.31	21	0.66		
Mean		1.22	0.61	1.56	0.67	22.01	0.02
Fracture (number)		10	31%	5	16%		0.23
Fixation		1 Screw ($n = 27$) (allografts/autografts)		2 Screws ($n = 31$) (allografts/autografts)			
Fusion	2	1.48	0.64	1.48	0.57	0.20	0.68
Resorption	3	2.33	0.96	2.81	0.48	16.86	0.03
Elevation	2	1.67	0.55	1.94	0.25	13.85	0.08
Total	7	5.52	1.85	6.23	0.96	11.36	0.09
Fracture (number)		7	26%	8	26%		0.55

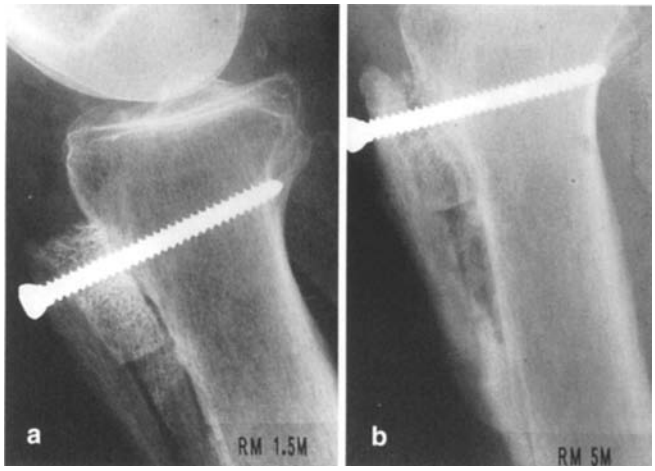

Fig. 4 a, b Partial resorption of this allograft around the screw and minor height loss after comparison of the X-rays at 1.5 and 5 months

Postoperative clinical charts were analysed for the average hospital stay, the first day of getting out of bed and the average amount of blood transfusion (Table 6). The average hospital stay was 12.1 days for the autografted patients and 9.3 days for the allografted ones ($P < 0.03$). Mean time interval to the first day of getting out of bed was 4.4 days after autograft and 3.4 days after allograft. After procuring graft material from the iliac crest, patients required a mean of 313 ml of transfused blood, whereas allografted patients received 241 ml. There was no statistical difference in the interval between surgery and the first day of standing nor in the quantity of blood transfused.

The use of analgesics for posteroperative pain, however, was greater in the autografted group, but could not be quantified. The satisfaction index was not statistically influenced by the type of graft nor by the radiological results. Six of the autografted patients (19%) experienced residual pain 6 months after the bone graft procurement from the iliac crest.

Discussion

Bone allografts did not differ from autografts when fusion, graft resorption and loss of elevation were monitored on radiographs for at least 6 months. The mode of fixation of the graft had more influence than the nature of the graft. Allografts fixed with two screws performed as well as au-

Table 5 Comparison of the radiological scores of autografts and allografts with one- and two-screw fixation. Radiological score observed with one-screw fixation after exclusion of cases with tibial cortexfracture

	Score	Allografts		Autografts		Difference (%)	*P* value
		Mean	SD	Mean	SD		
Two-screw fixation		($n = 10$)		($n = 21$)			
Fusion	2	1.60	0.52	1.48	0.51	8.40	0.35
Resorption	3	2.80	0.63	2.81	0.40	0.36	0.97
Elevation	2	1.90	0.32	1.95	0.22	2.66	0.59
Total	7	6.30	1.25	6.19	0.81	1.78	0.67
Fracture (number)		2	20%	6	28%		0.86
One-screw fixation		($n = 19$)		($n = 8$)			
Fusion	2	1.42	0.69	1.63	0.52	12.55	0.46
Resorption	3	2.26	0.99	2.50	0.93	9.48	0.57
Elevation	2	1.58	0.61	1.88	0.36	15.79	0.21
Total	7	5.26	2.02	6.00	1.60	12.28	0.37
Fracture (number)		7	37%	0	0%		0.04
One-screw fixation without fracture		($n = 12$)		($n = 8$)			
Fusion	2	1.82	0.40	1.63	0.52	11.88	0.79
Resorption	3	2.64	0.67	2.50	0.93	5.44	0.79
Elevation	2	1.91	0.30	1.88	0.35	1.81	0.82
Total	7	6.36	1.03	6.00	1.60	6.07	0.55

Table 6 Mean clinical data observed in auto- and allografted tubercle elevation

	Autografts ($n = 32$)		Allografts ($n = 32$)		Difference (%)	*P* value
	Mean	SD	Mean	SD		
Mean hospital stay (days)	12.1	3.9	9.3	4.6	30.11	< 0.03
Time interval to the first day of getting out of bed (days)	4.4	1.3	3.4	1.3	29.41	> 0.05
Blood transfusion (ml)	313	375	241	279	29.88	> 0.05
Satisfaction index (max. 3 pts)	2.09	0.96	2.45	0.72	14.60	> 0.05

Fig. 5 Postoperative radiograph of an autografted knee showing poor filling of the cavity

tografts. One-screw fixation resulted in greater resorption for both types of grafts, suggesting that immediate stability is more important than the type of graft used [9, 12]. Occurrence of a tibial cortex fracture in allografts fixed with one screw resulted in a more significant graft resorption and loss of elevation due to less stable fixation. The cause of the fracture was not clear, but it is likely that attempts to place a large bone block (it was so delivered) resulted in a higher number of fractures of the elevated tibial cortex. Finally, the less successful results in both groups, whatever the mode of fixation, were always favored by inappropriate grafting techniques: incomplete filling of the cavity or poor contact with host bone (Fig. 5).

Provided that a good fixation technique was followed, allografts could achieve an excellent fusion due to their osteoconductive capacity. It has been demonstrated that the processing of bone (removing the bone marrow and cellular debris) facilitates a more rapid invasion of the graft, although it had no positive effect on the amount of new bone [3, 15]. The cancellous bone of the upper tibial extremity also represents a very favourable osteogenic environment for graft invasion and can explain the absence of a significant difference with an autograft. A similar result would not be expected in a less osteogenic environment such as that found with posterior lumbar arthrodesis or cortical bone. In this series, most of the healing troubles observed were located at the tibial cortex/bone graft interface rather than at the cancellous bone/bone graft interface. It is very important to remember that bone allografts have only an osteoconductive property and no osteoinductive capacity. Graft invasion by osteogenic cells relies critically on the recipient graft bed, and therefore, an appropriate technique of implantation and an extensive and close contact with the recipient bone are required [13]. We believe that an allograft can achieve the same predictable result as an autograft if an immediate stable fixation is supplied by an appropriate mode of fixation [4, 14].

From the clinical data, it appears that patients receiving an allograft started standing earlier and left the hospital 2.5 days before patients with an autograft. These differences could be explained by the pain after iliac bone procurement. Six autografted patients were still complaining of pain at the procurement site 6 months after surgery, which is usual. De Palma et al. noted a 9% incidence of acute donor-site complications, and 36% of their patients felt persistent donor-site pain at 1 year [7]. Enneking et al. reported a 5% incidence of morbidity and disability at the site of graft procurement [10].

If the difference was not significant for the time to the first day of getting out of bed, it is because a draining tube was systematically left in the surgical site for 2 days. Patients of both groups started walking on the third day without any difference in the schedule of rehabilitation because the pain at the iliac crest was bearable.

The amount of transfusions required by the patients in this study was unexpectedly high for an advancement of the anterior tibial tubercle that did not cause much bleeding, except possibly at the bone procurement site in the autografted group and after lateral patellar release in both groups. Considering the mean difference, autografted patients required 30% more blood than the autografted ones. This trend is confirmed by many authors who used freeze-dried bone allografts, particularly in the treatment of scoliosis [8, 11, 19]. With the use of allograft, shortening of the operation time is also claimed but could not be investigated in one study [20].

Disease transmission represents a potential biohazard with the use of allografts. In this regard, donor selection and biological testing are mandatory. The processing of the bone is detrimental to viruses such as HIV and hepatitis virus, because the use of detergents offers an additional safety barrier against viral transmission from a selected donor before sterilisation. This has been demonstrated in a case of HIV transmission by a seronegative organ donor in which fresh-frozen bone transmitted the virus while freeze-dried processed bone did not [18]. This organ donor was infected by HIV but had not detectable serum marker at the time of donation.

Reliability concerning bacteriological sterilization is also of prime importance: sterilization of human bone by irradiation has been performed for 14 years without any reported incidence of infection due to the graft itself [5]. No infection has been recorded in this study.

The study of preserved and treated allografts appears reliable in orthopaedic surgery, clinically as well as radiographically, avoiding the possible side-effects of bone autograft procurement and shortening the hospital stay, as evidenced in this study.

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