Are bone autografts still necessary in 2006 ?
A three-year retrospective study of bone grafting

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Autograft is considered as the gold standard in bone grafting. However, the development of tissue banks has allowed for a wider use of bone allografts, with good results. Demineralised Bone Matrix (DBM) and recombinant human Bone Morphogenetic Proteins (rh-BMP's) were also introduced to replace the time-honoured autograft. Is there currently still a place for bone autograft ?

The authors reviewed the orthopaedic surgical activity in their institution during the period 2003-2005, and traced all the surgical procedures in which bone grafting was performed. Tracking forms from the tissue bank were reviewed to assess the surgical indications.

Between 2003 and 2005, the use of autografts decreased from 1.3% to 0.9% of all surgical interventions, particularly owing to their decreased use in primary fusions, while the use of allografts increased from 10.7% to 12.7%. Indications for allografts covered all fields of orthopaedic surgery, including nonunions. Processed allografts represented 90% of all grafts used. DBM and rh-BMP were used on an exceptional basis.

There is currently a trend for surgeons to use allografts as substitutes for autografts, as processing of the allografts increases their safety while preserving most of their biological and mechanical properties. Autografting is now limited to revision operations after failed fusions, and to combined use at the junction with massive allografts. DBM and rh-BMP are still controversial but they might replace autografts, even in their currently remaining indications, if their cost effectiveness and efficiency are established.

Keywords : autograft ; allograft ; Demineralised Bone Matrix ; recombinant human Bone Morphogenetic Proteins.

INTRODUCTION

There is currently an increasing interest in bone allografts, due to the development of bone banks in many countries. Surprisingly, scarce data are available with regards to the respective use of autografts and allografts.

Autografts are still considered as the gold standard in bone grafting. Nevertheless, their availability is limited and their procurement results in significant donor site mobidity [2]. Allografts are more

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easily available, but stringent standards are necessary, given the potential risk of infectious diseases or allogenic reactions (*9*). Bone allografts are not osteogenic, which may explain their slower integration in the host bed. Demineralised Bone Matrix (DBM) and recombinant human Bone Morphogenetic Proteins (rh-BMP's) become more and more popular in Europe, because they are osteoinductive, so that they might replace autografts in some of their indications in the future (*10, 18, 20, 23*). This study was undertaken in an attempt to assess the current use of bone autografts in our institution.

METHODS

All auto- and allograft procedures performed in 2003, 2004 and 2005 in the authors' institution were traced. The indications were obtained from procedure forms and operative notes. The relative frequency of allograft use was assessed from the tracking forms returned by the surgeons after graft implantation. The tissue bank tracking form indicated the type of implanted graft, its purpose and its anatomical location.

A Chi-square test was used to assess the evolution over time in the relative use of autografts and allografts, and also in the relative use of the various types of allografts available.

RESULTS

Bone grafting procedures were very common in the authors' institution in 2005 : they represented 13.6% of all orthopaedic operations (table I). Allografting procedures were about 10 times more frequent than autografting procedures (table I). Moreover, the use of allografts clearly increased during the period 2003-2005, whereas the use of autografts decreased (table I) (p < 0.001).

Table I. — Percentage of autografting and allografting procedures in the authors' institution during the period 2003-2005

	2003	2004	2005
All orthopaedic procedures	**3,730**	**3,987**	**4,082**
Autografts	1.3%	1.2%	0.9%
Allografts	10.7%	11.2%	12.7%

Table II. — Types of and indications for autografts in the period 2003-2005

	2003	2004	2005
All autografts	**47**	**46**	**35**
Iliac crest grafts	46	38	30
1st arthrodesis/ non-union	80.4%	60.5%	46.7%
Revision arthrodesis/ non-union	8.7%	18.4%	10.0%
Combined with massive allograft	10.9%	21.1%	43.3%
Free vascularised transfer	1	8	5

Table III. — Indications for allografts during the period 2003-2005

	2003	2004	2005
Allografts	**551**	**611**	**727**
Trauma	36.3%	35.2%	34.9%
Spine fusion	23.2%	23.2%	25.0%
Revision arthroplasty	18.5%	19.5%	18.5%
Tumour surgery	9.4%	10.1%	8.%
Nonunion	9.2%	9.3%	9.6%
Miscellaneous	3.8%	2.8%	3.3%

Most autografts were classical iliac crest grafts, and only rarely free vascularised grafts (table II). The use of iliac crest grafts in primary operations clearly decreased, while the combined use of autografts and massive allografts increased (table II).

The indications for allografting remained unchanged during the period 2003-2005 (table III) : trauma, vertebral fusion and revision arthroplasty were the main indications, in this order.

The types of allografts used changed significantly during the period 2003-2005 (p < 0.001) (table IV). Freeze-dried bone was used most frequently, in about 80% of the cases. The use of fresh frozen femoral head allografts, Demineralised Bone Matrix (DBM) and rh-BMP remained marginal.

DISCUSSION

Autografts remain for many the gold standard in bone grafting because of their immediate availability and high success rate (*18*). Major restrictions are

Table IV. — Relative use of various types of allografts as
well as DBM and rh-BMP during the period 2003-2005

	2003		2004		2005	
Allografts	**551**		**611**		**727**	
Freeze-dried	468	84.9%	499	81.7%	573	78.8%
Massive allografts	42	7.6%	63	10.3%	69	9.5%
Frozen processed FH	15	2.7%	42	6.9%	66	9.1%
Fresh-frozen FH	8	1.5%	4	0.7%	7	1.0%
DBM	18	3.3%	3	0.5%	12	1.6%
rh-BMP	3		0		0	

FH = femoral heads.
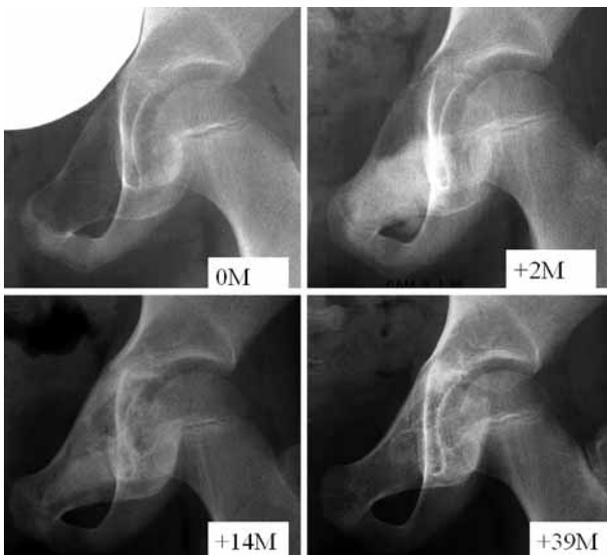
Fig. 1. – This 8-year- old girl presented with an active aneurismal cyst of the pelvis, treated by injection of DBM mixed with bone marrow. Complete healing was observed at 39 months.

Fig. 2. – Vertebral osteotomy for sequelae of L2 burst fracture. The lateral radiograph shows osseointegration of cortical ring femoral allograft after 5 years.

their limited availability and the donor site morbidity. In their meta-analysis Banwart *et al* (*2*) reported minor complications at the donor site in 39% and major complications in 10%. These drawbacks are to be balanced against the expected benefits. The autograft is usually described as osteoconductive, osteogenic if grafted rapidly, and minimally osteoinductive. These properties account for both their fast integration and re-vascularisation. However, complete graft integration is an illusion, as large areas of necrotic bone were observed in biopsy specimens obtained 18 to 20 months after impaction bone autografting for vertebral collapse (*44*). This is why, in our institution, we use allografts for most indications, all the more as similar results are obtained as with autografts.

Allografts are procured either from living donors (mostly femoral heads because of their availability during hip arthroplasty) or from human cadavers. Their potential morbidity mainly consists of the transmission of pathogens, particularly viruses ; those most feared are HIV, HBV, HCV and HTLV (Human T Cell Leukemia/Lymphoma Virus) (*9*). However, processing of the grafts removes blood and bone marrow in which the viral agents reside. By the same token, processing also protects against rhesus-immunisation. Processing consists of techniques such as low-dose irradiation, physical

Fig. 3. – This 9-year-old girl presented with a severe planovalgus left foot. She underwent a lengthening osteotomy of the calcaneus with cancellous irradiated freeze-dried allograft and temporary wires. Excellent radiographic and clinical results.

Fig. 4. – This 62-year-old male patient suffered from chronic tibial osteomyelitis. A 10-cm long segment of the tibial diaphysis was resected and the defect was filled with a massive tibial allograft, with intramedullary static nailing and autologous bone marrow cells at the junctions. The patient returned to normal activity.

debridement, pulsatile water washes, ethanol treatment and an antibiotic soak. Bacterial transmission has also been reported in a few cases (26, 28, 31). Bone banks apply standard protocols which reduce these risks. The risk of viral transmission with unprocessed deep-frozen, non-irradiated grafts from screened donors is currently less than 1:1 million for HIV and 1:200,000 for HCV. It is virtually non existent for processed bone grafts. Their safety, availability and easy storage all make allografts very attractive. Allografts may be freeze-dried (under low temperature and low pressure) or conserved at -40°C or less. The processing and storage techniques may affect the properties of the allograft in different ways. Lipid extraction with solvents does not alter the mechanical properties of cancellous bone and produces a bone material that is better incorporated than a non-defatted allograft (46).

Freeze-drying combined with final irradiation reduces the ultimate stress and plastic deformation capacity (8). Irradiation within normal limits does not affect the compressive mechanical properties of fresh-frozen human cancellous bone (1). These observations explain why there is a tendency towards using frozen processed allografts. Their availability, mechanical strength, improved osteoconduction and safety convinced our group to increasingly use allografts rather than autografts,

even for primary surgeries. Good stabilisation of the allograft, perfect contact with the host bone and sufficient vascularisation all are determinants of success, as shown by clinical studies (7).

Demineralised Bone Matrix (*DBM*) results from the decalcification of cortical allografts. The obtained material contains collagenous and non-collagenous proteins, including bone growth factors known as BMP, TGF-beta and IGF-1. These growth factors are responsible for its osteoinductive properties. DBM has been widely studied and has been found to be efficient in animal models (3, 14, 24, 47). A study comparing the efficacy of various commercially available DBM types showed highly variable results according to the type of DBM used (35). Bridging of a critical fibula defect in man with DBM and OP-1 bone morphogenetic protein has been reported (20). Several case series have reported bone formation in man (45, 47-49), but a randomised study demonstrating a clear advantage of DBM is still lacking. This is why the authors reserve the use of DBM for specific indications, such as aneurysmal bone cysts (12).

The s*pine* is one of the regions where allografts are of upmost importance. In anterior fusion of the cervical spine, the number of levels fused and the use of instrumentation appear to be the determining factors for success or failure, while there is no clear evidence that autografts are superior (4, 17, 30, 37, 43). As far as spondylolisthesis is concerned, Wimmer *et al* (50) found no significant differences between allo- and autografts, while Gibson *et al* (21) preferred allografts, because they gave similar results without donor site complications. Convergent studies comparing allografts with autografts in scoliosis surgery (13, 15, 32, 36) concluded to the superiority of allografts. Reconstruction of large anterior vertebral column defects is indicated in a number of pathological conditions. Munting *et al* (34) concluded that freeze-dried, irradiated cortical allografts were safe and effective for anterior reconstruction of large spinal defects.

As to *revision arthroplasty of the hip*, cavitary defects can be reconstructed with morselised allografts, but segmental defects require cortical or corticocancellous allografts in order to provide structural support (19, 22). Acetabular reconstruction

with bulk bone grafts showed poor but similar long term fixation of the acetabular component for both allo- and autografts, after 16 years (40). Gamardt *et al* (19) and Sloof *et al* (41) concluded that no particular type of bone graft was superior, when non-structural grafts were needed. A recent series showed similar results with frozen irradiated bone, freeze-dried and fresh frozen allografts in acetabular revision surgery (5).

Failed *total knee replacement* often requires bone grafting because of the associated bone loss. Small cystic bone defects in the femur and tibia are ideally filled with impacted autografts obtained from the revision. Morselised allografts are an alternative for these small bone defects, and most authors report excellent results (38). If the defect is too large, similar results are obtained with autografts alone or autografts mixed with allografts (38, 42). Segmental condylar bone loss requires a massive segmental allograft, a modular implant or both.

In *trauma* surgery, depressed tibial plateau fractures are successfully treated with allografts (27, 39). Displaced intra-articular calcaneal fractures are commonly bone grafted, without evidence of autograft superiority. A review study of 86 subtalar arthrodeses following intra-articular calcaneal fracture concluded to a similar fusion rate regardless of the graft material used and regardless of the fracture type (16). The good results with allografting in other types of calcaneal surgery confirm its value in the treatment of these fractures (29, 33).

Non-unions are usually treated with autografts. However, in the authors' institution, non-unions have been regularly treated with allografts : massive allografts in case of structural defect or processed allografts with bone marrow aspirate. Positive reports on the efficiency of bone marrow aspirate (25) and the improved bone osteoconduction of processed bone may explain this choice. DBM and rh-BMP were rarely used. The authors preferred using autografts to enhance bone ingrowth into massive allografts, and also for revision surgery after failed fusion, as DBM and rh-BMP were not efficient in their hands, at least not in these situations (11). This is in sharp contrast with the fact that several animal studies (3, 6, 14, 24, 47, 51) showed similar or better results when DBM

or rh-BMP were used for the treatment of non-unions or segmental bone defects. These encouraging results suggest that these osteoinductive agents might replace autografts in the treatment of nonunions in the future. The clinical comparison of fresh autografts and Osteogenic Protein-1 (bone morphogenetic protein-7, or OP-1) in the treatment of tibial non-union showed similar clinical and radiographic results in both groups of patients (*18*).

CONCLUSION

The use of autografts in orthopaedic surgery is currently becoming narrower, given the availability of safe and efficient bone allografts. Autografts should still be used in revision surgery or in combination with massive allografts at the junctions between the graft and the host bone. However, even for these indications DBM and rh-BMP might replace autografts in the future, if their effectiveness and cost- efficiency ratio are clearly established.

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