AUTOLOGOUS BONE GRAFT FOR TIBIAL DEFECTS ON KNEE TOTAL ARTHROPLASTY

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SUMMARY

Osteoarthrosic knees with large bone defects usually develop as varus or valgus deformities, with daily functional disabilities such as pain, instability and limping. Between March 1996 and January 2003, 19 knees of 18 patients were treated through primary total knee arthroplasty using autologous bone graft using the Sculco modified technique to correct large tibial defects. Sixteen knees were assigned to group II and three to group III, according to the classification used in our medical service. Post-operative follow-up period ranged from eight to 82 months, with an average of 53.73±23.43 months. Postoperative outcomes were similar to those of the primary arthroplasties, with early bone graft incorporation, within an average of 7.58±1.87 months. Collapse was seen in one knee during bone remodeling stage, without infection. The range of motion was between 90º and 125º, with an average of 105.27º±9.47º and the femoral tibial angle was between 170º and 180º, with an average of 175.33º±2.57º. Valgus angle ranging from 3º to 8º was obtained in 73% of the treated knees. The purpose of this study is to assess the effectiveness of the Sculco modified technique in correcting large tibial defects with autologous bone graft through clinical and radiographic observation.

Keywords: Knee; Knee Arthroplasty; Autologous bone graft.

INTRODUCTION

Knees affected by important bone gaps also present with angle deformities in varus or valgus, causing functional limitations such as pain and limping, as well as instability, during daily activities.

In advanced osteoarthrosis, a bone loss usually exists at the tibial and/or femoral condyle of various etiologies[1], such as primary arthrosis, fractures sequels, erosive diseases, rheumatic diseases and avascular conditions.

Currently, this kind of deformity with bone loss is becoming infrequent, since indications for prosthesis are made earlier, no longer waiting for the patient to achieve esthetic and functional disability, in addition to other factors such as improvements on components design[2], good cementation technique and accurate instruments, which increases prosthesis duration levels[3].

In the past, since arthroplasties used to present not so good outcomes[1,4], many knees with arthrosis resulted in large bone losses, with varus or valgus deformities and instability. By reviewing literature, we found three phases of knee arthroplasty: the first, related to the materials interposing technique between osteotomy lines; the second, resulting from the gaps and other noticed problems, corresponding to hinged prosthesis, and the third, when the prosthesis replacing joint surfaces emerged, which are currently used by us.

Appropriate surgical techniques recommend a good alignment of the knee angle in frontal plane, near to a valgus of five to seven degrees, ligamentous equalization, precise cuts according to the guides, a good support of the components in order to avoid deepening, bone defects compensation by various materials when necessary, and a good cementation[18].

It is unanimous among many authors[5-14] the indication of bone grafts in large gaps reaching over 50% of a tibial condyle and values above five millimeters of depth.

Many knees with large tibial defects require technically difficult procedures and the chances of a bad positioning are high, because, additionally to the losses, in many cases, they are associated to internal or external torsions around the tibial long axis.

The filling of the bone gap can be performed with different materials, according to surgeon indication and experience. In addition to autologous and homologous bone grafts, there is the methylmetacrilate cement used with or without fixation devices with synthesis materials, polymethylmetacrilate wedges, metal wedges in modular prosthesis and tailor-made prosthesis[15].

The objective of this study was to evaluate the efficiency of the Sculco modified technique for the correction of tibial defects with autologous bone graft through clinical and radiographic studies.

MATERIALS AND METHODS

Materials

In our series, 19 corrections of bone defects in primary prosthesis with autologous bone graft were performed in 18 patients within the period of March 1996 to January 2003 (Table 1).

Regarding gender, 14 (78%) were women and four (22%) were men.

Ages ranged from 55 to 77 years old, with an average of 66.10 ± 6.78 years old.

Regarding the knee, 12 (63%) were right and seven (37%), left.

Concerning tibial condyles, 16 (84%) were medial and three (16%), lateral.

Concerning pathology, 17 (90%) knees presented with primary osteoarthrosis and two (10%), rheumatoid arthritis.

According to the classification of bone defects used in our service(16), 16 (84%) belonged to Type II and three (16%), to Type III (Table 2).

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Post-operative follow-up time ranged from eight to 82 months, with an average of 53.73±23.43 months.

Method

Surgical Technique

All patients were submitted to total primary arthroplasty of the knee, with cemented prosthesis and wedges of autologous bone grafts, through the Sculco modified technique.

The osteotomies on the femoral, tibial and patellar condyles surface are performed according to the guidelines determined by instruments guides. Ligamentous equalizations and release of the soft parts are made whenever necessary.

Sculco modified technique

In this technique variant, the regularization of bone defect ends is performed, by resecting as minimal amount of bone as possible. The subchondral bone, sclerotic and avascular, is blooded with beveled chisel or pneumatic saw and holes are made with a ¼" drill.

With the intention of creating an ideal surface for the prosthesis, the bone gap is filled by the autologous graft, obtained from bone cuts of femoral condyles and located at the receptor area, without threads or screws fixation. The prosthesis is cemented over tibial condyles, restraining the graft (Figures 1 and 2).

In two cases where a bone defect larger than half a tibial condyle existed, an intramedullary extension nail about 70 mm long was associated, intending to disperse 30% of the vertical load applied on the prosthesis and to improve fixation and stabilization of the tibial component (Figure 3).

Post-operative

Patients were evaluated on the post-operative period regarding flexion range, femorotibial angle, initial incorporation of the graft through radiographic observation and possible clinical complications (Table 3).

Radiographic evaluation

Knee radiographs on immediate post-operative period are evaluated aiming to check graft positioning on tibial bone gap.

Other future evaluations are performed at each two months and, when required, in a monthly basis, aiming to check the initial bone incorporation through the transposition of the osseous trabeculate of host bed to the bone graft.

RESULTS

Initial union and incorporation of bone grafts was achieved in the 19 knees, which occurred within a period of four to 12 months, with an average of 7.58±1.87 months. Graft #19 (5%) incorporated within four months and grafts 1, 14, 16, 17, and 18 (26%) incorporated within a period of six months; grafts 3, 4, 6, and 13 (21%) within seven months; grafts 2, 5, 8, and 15 (21%) within eight months; grafts 9 and 10 (10%) within nine months; grafts 7 and 11 (10%) within 10 months and graft # 12 (5%) within 12 months (Table 4).

Flexion range was 90° - 125°, with an average of 105.27°± 9.47° and the femorotibial angle ranged from 170° to 180°, with an average of 175.33°±2.57°. We noticed an angle of three to eight degrees valgus in 73% of operated knees.

As a complication, there was one (5%) case of fragmentation with absorption, which occurred in the 18th month post-operatively, during the bone remodeling phase. There was no case of infection.

Knee	Age	Gender	Side	Plane	Disease	Classif.	Post-op.
1	55	F	R	med/.lat.	RA	III	82 months
2	55	F	L	med./lat.	RA	III	80 months
3	65	F	R	med.	OA	II	75 months
4	68	M	R	med.	OA	II	74 months
5	63	F	L	med.	OA	II	71 months
6	63	F	R	med.	OA	II	71 months
7	72	F	R	med.	OA	II	66 months
8	68	F	R	med.	OA	II	64 months
9	67	M	R	med.	OA	II	62 months
10	64	F	L	lat.	OA	II	57 months
11	73	F	L	med.	OA	II	55 months
12	77	F	R	lat.	OA	II	53 months
13	58	M	L	med.	OA	II	52 months
14	61	F	L	med.	OA	II	52 months
15	67	F	R	med.	OA	II	51 months
16	58	M	R	med.	OA	II	28 months
17	74	F	L	lat.	OA	II	11 months
18	73	F	R	med./lat.	OA	III	09 months
19	75	F	R	med.	OA	II	08 months
Average	66.10 ± 6.78 years old						53. 7 ± 23. 43m onths

Source: HMCC
Labels: F= female; M= male; R= right, L= left; med.=medial; lat.= lateral; RA= rheumatoid arthritis; OA= osteoarthrosis; Classif.= classification; Post-op.= post-operative

Table 1 - *Studied patients' profile.*

Kind	# of Compartments	Depth
I	1 or 2	Superficial
II	1	Deep
III	2	At least 1 deep (1 or 2)

Source: HMCC
Adapted from Kawano et al[11]

Table 2 - *Bone gaps classification.*

DISCUSSION

Many materials with various techniques have been described[1,7,9,11,12,14,15,17], with the objective of compensating primary or secondary bone defect. McKeever[18], provided one of the first reports on the use of autologous bone graft obtained from the iliac crest for repairing bone gaps on tibial condyle surface.

Surgical techniques

There are many techniques used for autologous or homologous bone grafts implants. Homologous bones come from bone banks duly tested and prepared, and the autologous grafts are taken from cuts performed on femoral and tibial condyles in primary prosthesis and, as an alternative, they can be taken from the iliac crest in blocks, both for primary lesions and for reviews.

Windsor et al.[14], described the technique recommended by Insall and the Sculco technique. In the Insall technique, a trapezoid-like fragment is taken at the bone defect site, and implanting an autologous or homologous graft with the same shape at that created space, fixing it with stainless threads, resulting in a flat surface on tibial condyle, which is ideal for cementing the prosthetic component. In the Sculco technique, which is one of the most used techniques today, a smooth surface is created through an oblique cut at the site of the bone loss with a pneumatic saw, placing the graft at that site and fixating it with stainless threads or screws. In our series, a variant for the Sculco technique was used.

The use of the Sculco modified technique in our study was due to the fact that this technique resects less healthy bone than the original technique; every time osteotomy is performed with the pneumatic saw at the bone gap site, a little anterior and posterior portion of the defect is removed with the sclerotic bone, because the defects don't present an oblique regular surface, but in the original technique this regularization is required.

Other materials

Many materials are used to compensate defects, such as: methylmetacrilate cement, with or without fixating screws; metallic modular wedges or tailor-made wedges provided with the prosthesis; polymethylmetacrylate wedges, and autologous and homologous bone grafts.

The material selection depends on each surgeon's experience and preferences, and, many times, the indication will be in accordance to the shape, size and depth of the bone gap.

Brooks et al.[15], studied the deflexion percentage that each material interposed in the defect could cause when a vertical force is applied on the set and they verified that the poorest results, with high rates of deflexion, occurred when methylmetacrylate cement, with or without fixating screws, was used. Polymethylmetacrylate and metallic wedges resulted in a good rate and were the best ones when tailor-made prosthesis was used. The interpretation of the results depends on the deflexion produced by the interposed material (the lower the rate, the stiffer the fixation).

The use of the 70-mm intramedullary extension nail in cases of large bone gaps is of great importance, because it absorbs the vertical compression force together with the cortical envelope in more than 30%, avoiding graft fragmentation and the collapse of the metaphyseal bone[15], providing a better stabilization and fixation of the prosthetic component, as well.

Bone graft

Homologous grafts

Homologous grafts present a relevant factor to be considered, because they trigger immunologic reactions on hosts, leading to a slower or partial incorporation, with a higher incidence of gaps compared to the autologous grafts[5,17].

The indication for autologous or homologous graft depends on surgeon's technical conditions, on the existence of a bone bank and on the amount of graft to be used. Care should be taken, however, when using homologous grafts because of the increased rates of infections and diseases transmission such as HIV, hepatitis B and C, syphilis, aerobic and anaerobic bacteria, and lymphocytic virus.

Knee	Graft Inc.	Flexion Angle	F. T. Angle
1	06 months	100º	176º
2	08 months	*	*
3	07 months	105º	175º
4	07 months	110º	178º
5	08 months	105º	174º
6	07 months	115º	177º
7	10 months	95º	173º
8	08 months	90º	175º
9	09 months	105º	178º
10	09 months	105º	178º
11	10 months	100º	177º
12	12 months	95º	180º
13	07 months	120º	174º
14	06 months	105º	177º
15	08 months	110º	175º
16	06 months	110º	175º
17	06 months	125º	172º
18	06 months	90°	170°
19	04 months	110°	172°
Average	7.58 ± 1.87 months	105.27° ± 9.47°	175.33° ± 2.57°

Graft Inc.= graft incorporation - F.T. Angle= femorotibial angle
* fragmented

***Table 3** - Post-operative Outcomes*

Months	Patients	Percentage
04	19	5%
06	01, 14, 16, 17, 18	26%
07	03, 04, 06, 13	21%
08	02, 05, 08, 15	21%
09	09, 10	10%
10	07, 11	10%
12	12	5%

***Table 4** - Initial graft union and incorporation times.*

Autologous grafts

Autologous grafts are a good option for repairing bone defects, because they are safe regarding diseases transmission, show a low infection and fragmentation rate, with short-term graft incorporation – because they are good osteoinductors and osteoconductor – without the additional cost of tailor-made prosthesis, and they do not produce immunologic responses such as those seen with the homologous grafts.

Bone incorporation

Union and incorporation

There is a consensus among reviewed authors concerning the indication for primary or secondary bone losses repair with autologous graft[7,9,14,15], which presents a short-term union and bone incorporation with good results.

When an autologous or homologous bone graft is used, its union and incorporation is expected, but biological meanings for these terminologies are different; the first is only the bone fusion between the graft and the host bone, and the second, the graft remodeling, which goes through many phases of progressive biological modifications until total replacement of the graft by host bone[5,17].

We highlight, among the various functions of the bone graft, the osteogenesis and mechanical support and, according to the purpose for which it is designed, a function may be more valuable than another. In our study, both were of great value, because, until incorporation, prosthesis support was provided.

Osteogenesis is the ossification seen by the graft replacement, mostly performed by cells proceeding from host bone, with the participation of bone graft cells on the interface with the receptor bed, which survive by diffusion. The great participation of grafts occurs on the process of osteoinduction and osteoconduction[17].

Incorporation time

The greatest post-operative expectation is about the autologous bone graft incorporation to the tibial defect, represented on radiographic studies by the transposition of the bone trabeculate to the implant[7,12,13], which, in our series, began with 7.58±1.87months average (Figure 4). Dorr et al.[7], achieved incorporation in six months, but they did not determine the time for full remodeling; Windsor et al.[14], mentioned the beginning of remodeling between four and eight months, and Wilde et al.[13], with homologous grafts, stated that the time for initial incorporation is variable, with the earliest case beginning in three months.

Incorporation phases

According to Goldberg and Stevenson[17], phases observed up to the remodeling or full incorporation are inflammation, revascularization, osteogenic induction, osteogenic conduction and remodeling.

Bauer and Muschler[5], reported that until full incorporation, the following is seen: hematoma organization, inflammation, blood vessels invasion, focal reabsorption by osteoclasts, and then, bone formation.

Fragmentation and absorption

Complications of most concern are the fragmentation of the graft with absorption, and infection. Regarding fragmentation, nonunion, and graft absorption, many authors[5,7,17] attributed those problems to alignment failure, non-equalization of soft parts, excessive loads and inappropriate preparation of the receptor bed, with deficiency on blooding of the eburneous bone, through perforations or simple resection, according to the techniques described, as main causes.

Figure 1 - *Area of the tibial hemicondyle defect to be filled with bone graft – intra-operative image*

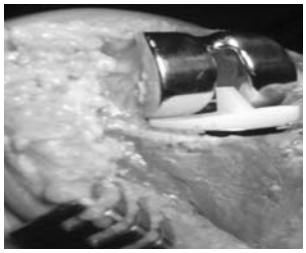

Figure 2 - *Total prosthesis – tibial component, cemented on the tibial condyle and the bone graft – intra-operative image*

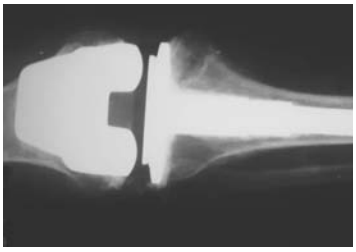

Figure 3 - *Total prosthesis with 70-millimeter intramedullary tibial extension nail – radiograph in anteroposterior plane*

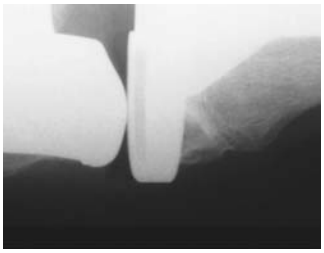

Figure 4 - *Incorporation of the autologous bone graft to the tibial defect – radiographic image evidencing bone trabeculate transposition.*

Dorr et al.[7], in 24 knees treated with autologous grafts, reported the occurrence of two cases of non-union and one collapse; Laskin et al.[9], reported in their series of 26 knees treated with autologous grafts, four fragmentation cases with absorption in the first year of follow-up, attributing this poor result to the size of bone losses and to the bad technique used regarding proper alignment; Mnaymneh et al.[10], in 14 knees treated with homologous grafts, presented two cases of non-union and fracture; Stockley et al.[11], also using homologous grafts, had two fractured grafts in 20 knees; Ghazavi et al.[8] noticed a fracture and a non-union with the use of homologous grafts in 30 knees submitted to review; Clatworthy et al.[6], in 50 knees treated with homologous grafts, had five cases of reabsorption and two non-unions. We had one case in a similar condition among the 19 autologous grafts in our series.

EVALUATION METHODS

Failures on remodeling bone grafts are basically determined by clinical follow-up, periodic radiographic controls, tomography, scintiscan and biopsy[5,7].

CLINICAL RESULTS

Alignment at frontal plane

Knee alignment at frontal plane is of crucial importance for prosthesis duration[19] and for a successful graft union and incorporation. Dorr et al.[7], consider the bad alignment as one of the main causes of such fragmentation, suggesting five to eight degrees of valgus as ideal; Windsor et al.[14], recommended between seven and nine degrees of valgus; Wilde et al.[13] and Tsahakis et al.[12], presented in their series an average result of four degrees of valgus. In our series, angles ranged from zero to ten degrees of valgus, with an average of 4.7°2.57°. We achieved a three to eight-degree valgus in 73% of the knees.

Flexion rate

Regarding flexion, Wilde et al.[13], had an average of '105°. Mnaymneh et al.[10], an average of 92°, ranging from 60° to 105°; Harris et al.[20], presented an average of 104°, ranging from 60° to 125°. In our series, we had a rate of 90° to 125°, with an average of 105.27° ± 9.47°.

Complications

As a complication, we had a case of graft fragmentation, for which reason was not determined. The patient has rheumatoid arthritis, takes immunosuppressive drugs and, in her surgery, a large bone graft was used, because her lesion was larger than half of the medial tibial condyle. Those factors may have contributed to cause this fragmentation and absorption.

CONCLUSION

The use of autologous graft through the Sculco modified technique constitutes a good method of biological repair in bone gaps of tibial condyles, with initial union and incorporation in the short-term, minimal incidence of fragmentation and absorption, allowing for good alignment rates at frontal plane and knee flexion.

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