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Original Article

Analysis of vascularized fibula graft integration to the extracorporeal irradiated bone after reimplantation: 2-year follow-up

Análise da integração do enxerto de fíbula vascularizada ao osso irradiado extracorpóreo após reimplante: acompanhamento de 2 anos

Análisis de la integración del injerto de peroné vascularizado en el hueso irradiado extracorpóreo después del reimplante: seguimiento de 2 años

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Abstract
Background: Major bone segmental defects in oncologic patients continue as a therapeutic challenge to orthopedic surgeons. The few alternatives for its management and the relation between functional outcome and surgical complication remain among the main restrictions for indication of different techniques. One of these alternatives is the vascularized fibular graft in association with the creation of a bone channel made from resection of the tumor bone segment after being submitted to the extracorporeal irradiation technique. There is little subject information about long-term follow-up either prospective than retrospective studies. Aim of the study: Retrospective evaluation of vascularized fibular graft consolidation capacity from diaphysis and metaphysis and its integration to irradiated bone after transplantation. Methods: eleven patients submitted to extracorporeal irradiation technique and reimplantation with vascularized fibular graft had their radiographic images on 6, 12 and 24 months of postoperative period evaluated. Results: we observed 41.1% integration in the first year and 58.8% in the second year of follow-up, progressive in the diaphysis focus and maintenance of the metaphysis focus. Conclusion: The fibula has a good capacity for bone integration, showing less influence on the consolidation of the metaphysis portion.
Descriptors: Bone Transplantation; Osteosarcoma; Microsurgery; Surgical Oncology.

Resumo
Antecedentes: Os principais defeitos segmentares ósseos em pacientes oncológicos continuam como um desafio terapêutico para os cirurgiões ortopédicos. As poucas alternativas para seu manejo e a relação entre resultado funcional e complicação cirúrgica permanecem entre as principais restrições para indicação de diferentes técnicas. Uma dessas alternativas é o enxerto fibular vascularizado, associado à criação de um canal ósseo feito a partir da ressecção do segmento ósseo tumoral após ser submetido à técnica de irradiação extracorpórea. Há pouca informação sobre o assunto em longo prazo, tanto em estudos prospectivos quanto em estudos retrospectivos. Objetivo do estudo: Avaliação retrospectiva da capacidade de consolidação do enxerto fibular vascularizado de diáfise e metáfise e sua integração ao osso irradiado após o transplante. Métodos: onze pacientes submetidos à técnica de irradiação extracorpórea e replantio com enxerto fibular Vascularizado tiveram suas imagens radiográficas nos 6, 12 e 24 meses de pós-operatório avaliados. Resultados: observamos 41,1% de integração no primeiro ano e 58,8% no segundo ano de acompanhamento, progressivo no foco da diáfise e manutenção do foco da metáfise. Conclusão: A fíbula possui boa capacidade de integração óssea, mostrando menor influência na consolidação da porção metafísica.
Descritores: Transplante Ósseo; Osteossarcoma; Microcirurgia; Oncologia Cirúrgica.

Resumen
Antecedentes: los principales defectos del segmento óseo en pacientes oncológicos continúan como un desafío terapéutico para los cirujanos ortopédicos. Las pocas alternativas para su manejo y la relación entre el resultado funcional y la complicación quirúrgica permanecen entre las principales restricciones para la indicación de diferentes técnicas. Una de estas alternativas es el injerto vascularizado de peroné en asociación con la creación de un canal óseo a partir de la resección del segmento óseo tumoral después de someterse a la técnica de irradiación extracorpórea. Hay poca información de los sujetos sobre el seguimiento a largo plazo, ya sea prospectivo que los estudios retrospectivos. Objetivo del estudio: Evaluación retrospectiva de la capacidad de consolidación del injerto vascularizado de peroné de la diáfisis y la metafisis y su integración al hueso irradiado después del trasplante. Métodos: once pacientes sometidos a técnica de irradiación extracorpórea y reimplantación con injerto vascularizado de peroné tuvieron sus imágenes radiográficas en 6, 12 y 24 meses de período postoperatorio evaluados. Resultados: observamos 41.1% de integración en el primer año y 58.8% en el segundo año de seguimiento, progresivo en el enfoque de diáfisis y mantenimiento del enfoque de metafisis. Conclusión: el peroné tiene una buena capacidad de integración ósea, mostrando menos influencia en la consolidación de la porción de la metáfisis.
Descriptores: Trasplante Óseo; Osteosarcoma; Microcirugia; Oncología Quirúrgica.

INTRODUCTION

Limb salvage is the standard technique for treating bone tumors since advances in chemotherapy and imaging have made this possible. There are synthetic and biological alternatives to replacing the resected bone segment.

Endoprosthesis reconstruction provides rapid return to limb function but presents high infection rates (10%) and its survival through looseness or wear is limited. However, 25% of patients require revision procedures in 10 years[1].

The use of homologous graft is a biological solution whereupon bone segmental defect is replaced by cadaveric bone. Despite prophylaxis there are no warrantees to run out the risk of disease transmission, and risk of immediate postoperative infection is similar to endoprosthesis. Another feared complication is graft fracture due to reabsorption occurring naturally in this devitalized bone segment. In addition, the difficulty of finding donor measures similar to the recipient requires the conservation of

large numbers of bones in the bank[2].

Extracorporeal irradiation and reimplantation is a technique in which patient's own bone segment was reimplanted after cleansing the soft tissues and tumor tissue and after irradiation in sufficient doses to cause complete cellular necrosis. Complications are similar to homohogous graft except for risk of disease transmission and perfect adaptation to the reimplantation site. From the oncological point of view, especially the risk of local and distant recurrence, the risks are also similar[3].

To promote the revitalization of the irradiated bone and to increase the mechanical stability of the reconstruction, a vascularized fibular graft can be implanted in the bone marrow channel. The major criticism of this alternative is the substantial increase in the complexity of surgery and surgical time[4,5].

There are no data in the literature on the integration of the fibula and its effect on the consolidation of the irradiated bone.

The aim of this study is the evaluation of integration capacity of the vascularized fibular graft to the irradiated bone after reimplantation.

MATERIAL AND METHOD

This cross-sectional study was approved by Ethics Committee (CAAE: 02607218.2.0000.5440). Inclusion criteria were patients submitted to the vascularized fibular graft procedure for limb reconstruction after resection of malignant bone tumors greater than 8 centimeters length. Exclusion criteria were cases where margin need to be extended to amputation due involvement or postoperative infection.

Twenty patients submitted to surgical treatment of malignant bone tumors using the extracorporeal irradiation by 50 Gray (Gy) and reimplantation technique with end-to-end arterial anastomosis from 2002 to 2011 had their medical records and radiographs analyzed. In nine cases it was not possible to evaluate all the data due to death or loss of radiographs films. In six cases, the irradiated bone included the articular surface and, therefore, presented only osteotomy at diaphysis. The mean of radiographic films analyzed was 24 months of postoperative period.

The patients were submitted to a preoperative assessment and evaluation of imaging exams to determine length of bone tumor, resection and reconstruction plan. The distal and proximal bone margin was 2 centimeters to the tumor which allowed the resection of compartments margin. After resection, bone specimen was submitted to macroscopic removing of all visible tumor from its external cortical. Marrow bone reaming was also performed progressively. Irrigation with ten liters of saline was performed and the bone fragment was irradiated with 50 Gray for 120 minutes. A channel was made on remaining bone to ensure that fibula could be inserted inside the marrow space. During this procedure on the recipient side, a vascularized fibular graft was raised in contralateral limb. The vascularized fibular graft was insert into the bone channel and reimplantation of sterile bone with end-to-end microsurgical anastomosis was performed.

The mean resected bone tumor length was 16,72cm ranged from 9 to 20 cm. Being 9 cm in proximal humerus, 19,5cm (ranged from 18 to 21 cm) in distal femur and 16,83 cm (ranged from 13 to 20 cm) in the proximal tibia.

There were no control groups or comparison with the results of another study, considering this a criticism of this study. The results were obtained through evaluation of radiographic films.

The study group consisted of 11 patients with a mean age of 19,7 years (11 to 53 years) of whom five were males. The preponderant diagnosis was the classical osteosarcoma with eight cases and the remaining three being parosteal osteosarcoma, lymphoma and leiomyosarcoma.

The postoperative protocol included an immediately rehabilitation program with toe-touch weigh bearing and full range of movement of joints. Partial weight bearing was introduced after three months and full weight bearing was permitted after evidence of consolidation on radiographic films.

Radiographs films at 6, 12 and 24 months of postoperative period were analyzed by three evaluators (one radiologist, one orthopedic surgeon and one hand surgeon) independently, without identification of postoperative time and it was observed bone callus formation, consolidation of osteotomy and signs of fibula integration. The fibula was considered integrated into the irradiated bone when it had bone bridges or fusion between the bones. The osteotomy focus was considered consolidated when it presented bone integration or complete disappearance of the osteotomy line.

RESULTS

Bone location, tumor diagnosis and length, and receptor artery of anastomosis are detailed on Table 1. Tables 2 and 3 present the indexes of integration, consolidation and presence of callus according to the bone location.

Fibular integration occurs in 41,1% of cases in first year, being 45,4% on diaphyseal focus and 33,3% on metaphyseal focus. The integration was 58,8% in second year of postoperative period, representing 72,7% on diaphysis and 33,3% on metaphysis.

Fibular integration observed in first year had increased in percentage on integration of diaphyseal focus and remained resembling in metaphyseal focus (Figure 1).

Table 1. Bone location, tumor diagnosis and receptor artery of anastomosis

Bone	Tumor and Length of Resection	Local of arterial anastomosis
Proximal Tibia	Classic osteosarcoma – 13cm	Anterior tibial artery
	Classic osteosarcoma – 15cm	Posterior tibial artery
	Classic osteosarcoma – 16cm	Anterior tibial artery
	Classic osteosarcoma – 18cm	Posterior tibial artery
	Classic osteosarcoma – 19cm	Anterior tibial artery
	Lymphoma - 20cm	Peroneal Artery
Distal Femur	Classic osteosarcoma – 18cm	Deep femoral artery
	Classic osteosarcoma – 20cm	Deep femoral artery
	Parostealosteosarcoma – 18cm	Deep femoral artery
	Leiomyosarcoma - 20cm	Deep femoral artery
Proximal Humerus	Classic osteosarcoma – 9cm	Deep brachial artery

Table 2: Results on diaphyseal focus

	Signs of Fibula Integration	Signs of Consolidation	Bone Callus
6 Months	3[11]	4[11]	1[11]
12 Months	5[11]	6[11]	3[11]
24 Months	8[11]	7[11]	4[11]

Table 3: Results on metaphyseal focus of Articular Segmental Bone

	Signs of Fibula Integration	Signs of Consolidation	Bone Callus
6 Months	2[6]	1[6]	0[6]
12 Months	2[6]	5[6]	0[6]
24 Months	2[6]	5[6]	1[6]

Figure 1: Integration of diaphysis focus and remained resembling in metaphysis focus.

DISCUSSION

The use of homologous grafts has been addressed more broadly in the literature than the use of extracorporeal irradiation. The association of vascularized fibular graft to the irradiated bone is a little studied subject and its radiological evaluation is made difficult because there are no well-established quantitative parameters for bone density and consolidation evaluation.

Non-consolidation rates of the homologous graft were reported between 7.6% and 29.8%, being higher in the diaphyseal bone and lower in the metaphyseal bone[7-11]. High consolidation rates (96%) were observed when there was an association between the homologous graft and the vascularized fibular graft[8]. In a study evaluating the healing of the irradiated and reimplanted bone, high rates of consolidation (94%) were observed in cases where vascularized fibula was associated and hypertrophy, and lower rates of consolidation (75%) when there was no association of the fibula vascularization or hypertrophy of the same[7].

In our study, it was also observed a shorter consolidation time in the metaphyseal portion when compared to the diaphyseal portion. In the metaphyseal portion, the osteotomy was consolidated in five cases within 12 months of follow-up, whereas in this period the diaphyseal osteotomy was only consolidated in six patients. However, it was observed that there was an increase in the percentage of consolidation of the diaphyseal osteotomy at 24 months of follow-up. The fibular integration occurred both in the metaphyseal bone and diaphyseal bone although integration was gradual on diaphyseal bone. The integration of the fibula allows to suppose that the bone has recovered its mechanical capacity and that the patient is able to return to its normal activity.

The limitations of this study are the small number of patients because death, loss of follow-up, radiographic examinations that couldn't be rescued and no complications were reported. The individual timing of weight bearing of each patient was not reported. More studies are necessary to present consolidation percentage on larger population, and a control group is necessary.

CONCLUSION

It was possible to identify that the fibula has good capacity of integration in the bone. That allows supposing that bone recovered its mechanical capacity and that patient become able to return to normal activity. The fibula has no influence on consolidation in the metaphysical focus and little collaboration with its revitalization.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interests.

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