Limb salvage by recycling the resected bone segment in malignant bone tumors

An essay
Submitted for partial fulfillment of Master Degree in Orthopedic Surgery

By

Dr. Khaled Abdelhameed Mohammed

M.B, B.CH.

Under the supervision of :

Prof. Dr. Sameh Ahmed Shalaby
Professor of Orthopedic Surgery
Faculty of Medicine
Ain Shams University

Dr. Tamer A. Fayyad
Lecturer of Orthopedic Surgery
Faculty of Medicine
Ain Shams University

Faculty of Medicine
Ain Shams University
2009

الملخص العربي

بعد الاستئصال الجزئي للاورام الخبيثة في العظام ، يحدث خلل كبير ينبغي إعادة بناؤه لإستعادة وظيفة الأطراف المتضرره. الخيارات الرئيسية للتعمير تتضمن الترقيع الذاتي ، والترقيع الخارجي والمعوضات الداخليه.

الترقيع الذاتي للعظام يمكن ان تكون مدممه ؛ عمليات الترقيع الذاتي المدمم تجرى الآن على نطاق واسع نتيجة لتطور الجراحات الدقيقه.

كما ان تدفق الدم يمكن ان يحافظ عليها وخلايا العظام المطعمه تبقى حيه ،و بالتالي فتكوين العظام و إندماج العظام يكون بصوره قوية.

وقد خلق هذا الإسلوب تحسنا ملحوظا في معدلات النجاح العلاجي. ونظرا للكميات المحدودة من العظام التي يمكن جمعها ، الا أنه يصعب أحيانا لإصلاح العيوب الكبيرة من العظام ؛ وفي هذه الحالات يتطلب الترقيع الخارجي للعظام او المعوضات الداخليه.

الترقيع الخارجي للعظام هي شكل من أشكال إعادة استعمال العظام غير الحيه.

الرقعه الخارجيه المجمده أو المجمده المجففه من العظام كانت تستخدم على نطاق واسع لانقاذ الأطراف في البلدان الغربية. رغم أن الكسور وعدم الإلتئام يمكن ان تخفض معدلات النجاح إلا أن وظيفه الأطراف يمكن صوغها مع الترقيع الخارجي للعظام .

الترقيع الخارجي للعظام يمكن أن يكون من الصعب الحصول عليه في بعض البلدان الاسيويه ، خاصة اليابان وكوريا ، لأسباب دينية أو إجتماعية .و لهذا فقد أستحدث عدة طرق تسمح باعادة استخدام عظام مستأصله للتعمير ، بما فيهاالاشعاع ، المحمات ، البستره، والمعامله مع النتروجين السائل.

إنقاذ الأطراف بواسطة إعادة تدوير الجزء المستأصل من العظام فى حالة الاصابه بأورام العظام الخبيثة

توطئه
مقدمه للحصول على درجة الماجيستير فى جراحة العظام

مقدمة من
الطبيب : خالد عبد الحميد محمد

تحت إشراف:

الأستاذ الدكتور: سامح احمد شلبي
استاذ جراحة العظام
كلية الطب
جامعة عين شمس

الدكتور: تامر عبد المجيد فياض
مدرس جراحة العظام
كلية الطب
جامعة عين شمس

كلية الطب
جامعة عين شمس
2009

Introduction

After resection of malignant bone tumors, large bone defects should be reconstructed to restore the function of the affected limbs. The main options for reconstruction include autogenous bone grafts, allogeneic bone grafts and endoprosthesis Autogeneous bone grafts may be vascularized, vascularized bone autograft operations are now performed widely as a result of the development of microsurgery. As blood flow can be preserved and the cells in the grafted bone remain alive, bone formation and bone fusion are vigorous. This technique has generated remarkable improvement in therapeutic success rates. Because of the limited amounts of bone that can be collected, however, it is sometimes difficult to repair large bone defects; in such cases, allogeneic bone grafts or endoprosthes is indicated. Allografts are a form of reconstruction utilizing dead bone. Frozen or freeze-dried bone allografts have been widely used for limb salvage procedures in western countries. Although fracture and non-union of the grafts can reduce success rates, acceptable functional limbs can be recreated with allograft.Allograft can be difficult to obtain in some Asian countries, especially Japan and Korea for socio-religious reasons. Therefore, recycling of affected bone has been adopted in Japan.

Several methods have been developed to allow re-use of resected bones for reconstruction, including irradiation, autoclaving, pasteurization, and treatment with liquid nitrogen. [1]

Autogenous recycled bone has many advantages over allograft regarding immunologic reaction, avoidance of disease transmission, and economic efficiency and easy accessibility.[2.3]

Autogenous recycling techniques involve the immediate reimplantation of resected bone after extracorporeal treatment, such as heating, freezing, and irradiation. The methods for devitalizing tumor cells in recycled autograft include heating by autoclave or pasteurization. Autoclaving, is extremely effective in killing tumor cells.[4] .

Because the supply of allograft is limited extra corporeally-irradiated autograft, autoclaving, pasteurization, and treatment with liquid nitrogen is used for reconstruction of defects after intercalary resection of malignant bone tumors. [5]

Aim of the essay

To overview limb salvage by recycling of the resected bone segment in malignant bone tumors as regard methods of recycling, including irradiation, autoclaving, pasteurization, and freezing of the resected tumor with liquid nitrogen with their results and complications.

Limb Salvage in Malignant Bone Tumors

Conventional amputation of a limb with a primary malignant bone tumor ensures the radical removal of the bone tumor but at the expense of an impaired body image and compromised functional outcomes. However amputation alone did not ensure a good survival outcome until the introduction of neoadjuvant chemotherapy and modern imaging techniques in the 1980s. With adjuvant or neoadjuvant chemotherapy for osteosarcomas, the lung metastasis rate of patients decreased and the 5year survival rate of patients increased to 50%-80%.[6]

Chemotherapy extends a patient's survival through decreasing the lung metastasis rate and the tumor size. Furthermore, modern imaging studies can clearly demonstrate the local extent of the tumor, thus providing a guide for wide resection with a proper surgical resection margin with the additional protection of chemotherapy. Most malignant bone tumors of the extremity involve the major joints, i.e., the knee or hip, and therefore reconstruction of both the bone and joint is required .Some patients may have a tumor located in the diaphysis or diaphysis-metaphysis junction. Therefore many limb salvage options have been developed for treating patients with malignant bone tumors of the extremities including

resection of the tumor followed by arthrodesis of the joint, reconstruction with any type of bone graft, endoprosthetic reconstruction, resection of the tumor followed by subsequent Ilizarov leg lengthening, and rotationplasty in some instances.[7]

However, the basic requirement of any limb salvage protocol is that it needs to be safe and effective in terms of local recurrence and clinical survival. The choice of a proper procedure needs to be made on an individual basis, by considering the radiological staging, pathological staging, and the clinical status. [8]

As compared to a conventional amputation, the limb salvage procedure requires reconstruction of the defect after wide resection of the tumor. Requirements of the technique of either bone reconstruction or joint reconstruction may differ, whereas they both have to provide a tumor-free and well-functioning limb. Each choice of a limb salvage operation has its own advantages and problems .In this article, the principles of limb salvage operations and reconstruction of limb defects after wide resection will be discussed. [9]

Basic goals for limb salvage procedures

For most malignant bone tumors involving the major joints, i.e., the knee or hip, or for tumors located in the diaphysis or diaphysis-metaphysis junction, any treatment option should offer the best expected survival rate, local control of the tumor, the best possible functions, a good body image, and psychological acceptance. [10]

Limb salvage operations in well-selected patients with primary bone malignancies have demonstrated equivalent results of both survival and local control of the tumor compared to amputation. [11]

Any limb salvage operation should only be allowed when wide resection of the malignant bone tumor with an adequate margin can be assured. The basic requirements for limb salvage operations include:(1) Excision of the tumor with an adequate margin, (2) a local recurrence rate equivalent to or less than that with amputation, (3) the administration of adjuvant therapy as scheduled, (4) a durable reconstruction, and (5) fewer local complications These basic goals of a limb salvage operation should always be taken into consideration before the deciding on a choice of an operation option. [12]

Limb salvage procedures

Each limb salvage procedure has its own advantages and drawbacks . Regardless of whether a limb salvage procedure is used to reconstruct a bone or a joint, such an operation should be decided based on individual considerations. Compared to bone reconstruction, reconstruction of a joint is more difficult because of limitations of available well-functioning structural graft material.[13]

**Resection arthrodesis*

Resection arthrodesis refers to wide resection of a local tumor near a joint followed by an arthrodesis procedure with an autograft or allograft and implant, using either an intramedullary nail or plate fixation. This procedure can provide a stable, pain-free limb immediately after the operation, and the patient can return to normal daily life activities and work soon after the operation. Therefore such a procedure may be suitable for adult patients who have physically intense occupations. However, resection arthrodesis results in sacrifice of the range of motion (ROM) accompanied by a potential risk of fracture or infection.In addition loss of ROM can limit many joint activities, such as squatting, and therefore may impair a patient's quality of life and ability to work to a certain

degree. Autografts are a common source for reconstructing a bone or joint, as well as for resection arthrodesis. [14]

**Autografting techniques*

Use of autografts avoids problems of tissue compatibility and immune rejection. They have better graft-host bone healing potential than other bone grafts. Autografting techniques can be used in some selected situations, for example, an iliac crest or fibula shaft for bone reconstruction after resection of some diaphyseal bone tumors. The fibular head can be used to reconstruct a distal radius tumor. However, the applicability of autografts for major joint reconstruction is limited due to scant availability. Another variant of the autograft operation uses radiation-treated specimens as the reconstruction material. [14]

**Allografting*

In consideration of the availability and massive structural graft, allografts are more convenient and available than autografts for reconstruction of a major joint or bone defect. However, allografts may induce immune problems, retard host-allograft bone healing, transmit bacterial and

viral diseases, develop late resorption of the allograft, have a limited source of special size, have legal limitations in some countries, etc. Allografts which can be used to reconstruct a joint have Osteochondral allografts which can be used to reconstruct a joint have rather acceptable function. ([15])

**Allograft-prosthesis composite technique*

Furthermore, the allograft-prosthesis composite technique is another option for joint reconstruction. This technique has the same advantages and disadvantages of allografts. It may also have prosthesis-unique complications, such as aseptic loosening, infection, etc. [(16)]

**Rotationplasty*

Rotationplasty, i.e., resection of a malignant tumor followed by reconstruction using a rotated limb stump and plate fixation, can provide biological reconstruction. This procedure is usually performed in pediatric patients. For example, a defect in the distal femur can be reconstructed using the proximal femur. A defect in the proximal femur can be reconstructed using180º rotation of the leg with the distal femur connecting to the acetabulum. Therefore the rotated ankle is used as the knee joint. Postoperatively, a comprehensive rehabilitation program and external

prosthesis are required since there are drawbacks with cosmetic problems, this procedure has been used less frequently in recent decades.[17]

**The Ilizarov leg lengthening technique*

The Ilizarov leg lengthening technique is a common procedure nowadays. It can also be used for lengthening bone stumps to treat wide bone defects after wide resection of a bone tumor in some selected patients. However, this procedure requires a long time to achieve a final status of bone healing. This procedure may preserve the joint in special conditions, i.e., when the joint segment can be preserved. However, most Ilizarov leg lengthening procedures end up with arthrodesis.[18]

**Microsurgical reconstruction*

Microsurgical reconstruction using a vascularized bone and soft-tissue graft may also be used to reconstruct a limb defect after wide resection of the malignant tumor. It is a highly technically demanding procedure and usually takes a long time. Although bone healing may be better than that with other bone grafting techniques, the availability of a bone graft is limited due to the size and length required. Furthermore, it is time-consuming, and the potential risk of

fracture is rather high because of the relatively thin dimensions. [18]

**Endoprosthetic reconstruction*

The applicability of major joint reconstruction using an autograft, a massive osteochondral allograft, and or an allograft-prosthesis composite is limited due to the scant source and each one's unique drawbacks. Therefore, reconstruction with a modular custom-made oncological endoprosthesis has become a common procedure nowadays. This procedure can provide a durable and functional limb immediately after the operation with a relatively low postoperative complication rate. Endoprosthetic reconstruction can avoid the potential for bacterial and viral disease transmission, achieve immediate rigid fixation, and allow early initiation of a postoperative rehabilitation program. Therefore, increasing numbers of patients are undergoing endoprosthetic reconstruction after resection of a malignant bone tumor and some other nonmalignant conditions. However, patients' long term survival and prosthesis survival both remain issues for patients with bone malignancies. These should be seriously considered in the future. [12]