Distraction Osteogenesis in Limb Salvage Following Tumor Resection

Essay

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Abstract

Limb salvage surgery is a new technique and became very popular since the 1980's and this is contributed to the advances in several fields, including imaging techniques, chemotherapy, and radiotherapy. Through these advances, as well as the advances in soft tissue reconstruction, patients with primary malignant bone tumours gained a chance for sparing their limbs from amputation. Efficient chemotherapy has made long-term survival possible after excision of malignant limb tumors, and has helped to reduce the margin of surgical excision. One of the new methods for limb salvage and reconstruction is Distraction Osteogenesis. Distraction Osteogenesis is a biologic process of new bone formation between the surfaces of bone segments that are gradually separated by incremental traction. Specifically, this process is initiated when distraction forces are applied to the callus tissues that connect the divided bone segments, and continues as long as these tissues are stretched. The traction generates tension that stimulates new bone formation parallel to the vector of distraction. The living bone regenerated in distraction osteogenesis eventually provides sufficient biomechanical strength, stability, durability and attachment for tendons, ligaments and muscles [4]. It also helps in expanding the tumor free margin by physeal distraction prior to resection and addresses the problem of limb-length discrepancy that follows tumor resection in skeletally immature patients. The effect of chemotherapy on bone regenerated by distraction osteogenesis is not serious. Age is no limitation as long as the patient has the potential to heal a fracture. Distraction osteogenesis is beneficial for patients with a good long-term prognosis and for growing children. It will become more attractive if the duration of the treatment can be shortened.

Keywords:
Distraction Osteogenesis
Limb Salvage
Tumor Resection

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- **DO** : Distraction Osteogenesis
- **TZ** : Target Zone
- **FIZ** :Fibrous Interzone
- **HBS** : Host Bone Surface
- **PMF** : Primary Mineralization Front
- **MCF** : Micro-Column Formation
- **DG** : Distraction Gap
- **DCT** : Distraction Consolidation Time

Introduction

Introduction

There has been a dramatic improvement in the survival rate of patients with bone tumors and in the success of limb salvage, as a result of progress in chemotherapy, radiological evaluation, surgical techniques and the technology of materials and implants. The challenge of providing long-lasting survival and function of limbs after reconstruction is now being met with biological solutions using living bone. The ideal reconstruction should have biological affinity, resistance to infection, sufficient biomechanical strength and durability [1].

Bone defects created by limb salvage procedures may be reconstructed by a variety of methods namely: auto-grafts, allo-graft, bone transport and prosthetic replacement. However the incidence of complications such as fractures, nonunion, deformity and infection is high and is directly related to the size of the defect and the use of chemotherapy [2].

The living bone regenerated in distraction osteogenesis eventually provides sufficient biomechanical strength, stability, durability and attachment for tendons, ligaments and muscles [4]. It also helps in expanding the tumor free margin by physeal distraction prior to resection and addresses the problem of limb-length discrepancy that follows tumor resection in skeletally immature patients [12].

Chemotherapy has definite adverse effects on auto-grafts and allo-grafts in delaying union and incorporation due its effect on healing and revascularization [1], the effect of chemotherapy on bone regenerated by distraction osteogenesis is not serious, as shown in the studies done by **Jarka** *et al* (1998) using radiological, histological and chemical tests on the effect of methotrexate on distraction osteogenesis in rats [5].

Subasi *et al* (1998) studied the effect of a chemotherapeutic regimen consisting of high dose methotrexate, bleomycin and cyclophosphamide on distraction osteogenesis in rabbits; they observed that these agents have no significant negative effects on distraction osteogenesis [7]. Nevertheless, distraction osteogenesis may potentiate the effect of chemotherapeutic agents, because with distraction osteogenesis the regional blood flow may be kept within the normal range or even increased [6].

Distraction osteogenesis is used in producing unlimited quantities of living bone directly from a special osteotomy or fracture by controlled mechanical distraction. The new bone spontaneously bridges the gap and rapidly remodels to a normal macrostructure for the local bone [18].

The highly modular fixators can direct the new bone formation in any plane, as the distraction osteogenesis always follows the vector of applied force [14, 15]. Age is no limitation as long as the patient has the potential to heal a fracture.

Aim of the Essay

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Distraction osteogenesis has been widely used for the treatment of leg length discrepancy, non- union, traumatic bone defects, deformity and osteomyelitis. Its use in musculoskeletal tumors has not been studied in details. The aim of our study is to review the literature regarding the advantages, applicability, surgical techniques, case selectivity and drawbacks of this technique used to bridge bone defects created following tumor resection.

Distraction Osteogenesis

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Definitions

Distraction osteogenesis is a method of producing unlimited quantities of living bone stimulated by the application of controlled mechanical distraction to bone, which could occur at the physeal plate or between vascular bone surfaces created by a special osteotomy. [48]

Corticotomy is a low energy osteotomy of the cortex, planned to preserve the local blood supply to both periosteum and medullary canal. [48]

Latency is the period of time after a corticotomy when the initial healing response bridges the cut bone surfaces, before initiating distraction. [48]

Rate is the number of millimeters per day at which the bone surfaces are distracted apart. [48]

Rhythm is the number of distractions per day, in equally divided increments, that total the rate. [48]

Bone transport is the regeneration of intercalary bone defects by distraction osteogenesis. [48]

Healing index means the number of months from operation to full, unaided weight bearing for each centimeter of new bone length. [48]

Historic background

Alessandro Codivilla, former director of the Rizzoli Institute in Bologna, Italy, is recognized as the father of distraction osteogenesis. In 1905 he reported lengthening shortened extremities by applying traction in stages with a calcanean pin after a femoral osteotomy, he stressed the need to gradually elongate the extremity [48].

In 1912, Codivilla's student **Vittorio Putti** described the "osteoton", a device used to lengthen the femur, after a femoral osteotomy pins were placed in the proximal and distal fragments of the femur and interconnected with a spring loaded mechanism that permitted gradual distraction. He too stressed the need for slow distraction [48].

In 1932, **Haboush** and **Finkelstein** described the use of Kirschner wires rather than pins, they also described a technique of osteotomy designed to maximally preserve the periosteum in order to promote healing [48].

In 1938, **Bosworth** was the first to recommend a post-osteotomy latency period before beginning distraction, he recommended 10 days which is unlike the latency period used today[48].

In 1963, the **Wagner** technique was introduced. *The first* of three sequential operations included a diaphyseal osteotomy and