

Distraction Osteogenesis in Dentistry

Distracción Osteogénica en la Odontología

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SUMMARY: Distraction osteogenesis is a technique for induction of new bone formation between two segments of a bone that presents wide possibilities of use in Dentistry. However, the available information on this subject is still scarce. The aim of this article is to review the literature related to bone formation, mechanically induced by distraction osteogenesis, in order to supply subsidies the agreement of this process.

KEY WORDS: Distraction osteogenesis; Bony formation; Dentistry.

INTRODUCTION

The distraction osteogenesis (DO) is a method developed for induction of new tecidual formation between two segments of a bone for a slow and gradual force of traction (Ilizarov, 1989a; Ilizarov, 1989b; Meyer *et al.*, 2001a), DO is defined as the creation of neoformed bone and adjacent soft tissue after the gradual and controlled displacement of a bone fragment obtained by surgical osteotomy. Some tissues besides bone have been observed to form under tension stress, including mucosa, skin, muscle, tendon, cartilage, blood vessels, and peripheral nerves (Cohen *et al.*, 1995; Constantino & Friedman, 1991).

The DO application has modified the treatment form of the congenital and acquired craniofacial defects. With the use of force vectors is possible to get a significant and steady bone remodel, in varied directions, without extensive surgical interventions (Klein & Howaldt, 1996; Mccarthy, 1994; Molina & Ortiz Monasteiro, 1995; Ortiz Monasteiro *et al.*, 1997; Pensler *et al.*, 1995; Polley & Figueroa, 1997; Rachmiel *et al.*, 1995). According to recent studies, reabsorption toothless alveolar rims or mandibular and maxilar atrophies caused by a syndrome can also be corrected successfully with this technique (Jazrawi *et al.*, 1998; Li *et al.*, 1999; Welch *et al.*, 1998; Yasui *et al.*, 1997) The distraction osteogenesis or DO (of the Latin *distractio*,

division, separation or was concentrated; of the Greek, *osteo*, bone and *genes*, generation) is not considered an enxertia. This technique only stimulates a bone growth that interposes and integrates to the remaining bone tissue in the area (Querido & Fan, 2004).

In the distraction process, there are 3 fundamental sequential phases in which different biologic phenomena are produced. These have been experimentally studied in bones of endochondral or intramembranous origin. Latency phase is the period between performance of osteotomy and start of the traction, during which soft callus is formed. Time periods usually applied range from 0 to 7 days and coincide with the initial events in the normal process of bone repair; Distraction phase is the period in which traction is applied to the transport bone fragment and the formation of new immature woven and parallel-fibered bone commences. This phase usually lasts 1-2 weeks, and the traction modifies the normal development of the regeneration process; and Consolidation phase is the period that allows the maturation and corticalization of the regenerated bone. In craniofacial bones, a 3-5 week phase is recommended for children and a 6-12-week phase for adults, although the appearance of bone with identical characteristics to those of the initial bone may take more than a year (Cohen *et al.*)

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Once the distraction is ended, the central fibrous and osteoid areas ossify and gradually mineralize in a largely intramembranous manner in facial bones, becoming immature bone that will form remodeling areas for transformation into mature lamella bone. In maxillary bones, the ossification is largely intramembranous, although foci of endochondral ossification have been reported by some authors. Such foci may result from the instability of the bone fragments or from a high distraction rate and do not interfere with the final regeneration, although this phenomenon has yet to be elucidated (Constantino & Friedman).

Cope *et al.* (1999) defined distraction osteogenesis as a process of new bone formation between the surfaces of two segments of a bone separate gradually for incremental mechanics traction.

The DO technique presents wide possibilities of use in some areas of Dentistry, as Surgery, Orthodontics, Facial Orthopedic and also in the Oral Rehabilitation where one of the major problems is the alveolar bone loss, the support for protheses, implantations and adjacent soft tissues. The aim of this article is to revise the literature related to bone formation, mechanically induced by Osteogenic Distraction, in order to supply subsidies for this process.

OVERVIEW OF DISTRACTION OSTEOGENESIS TECHNIQUE.

More than 2000 years ago, Hipócrates was credited by describing the mechanics manipulation of the segment bone breaking. In the century XIV, Guy de Chauliac was the first one to study the continuous traction for reduction of breakings. The concept of osteotomies was established in the century XIX when Malgaigne described the concept of the external setting in the treatment of patelares composed breakings (McCarthy *et al.*, 2001).

The Osteogenic Distraction is a method developed for induction of new bone formation between two segments of a bone for a slow and gradual force of traction (Campisi *et al.*, 2003). It can be classified in two basic types: the fisal distraction, that involves the epiphysis and diaphysis of a long bone separation, and the calotasis, that consists of the gradual distension of a bone callus formed around the line broken or osteotomic stimulating and keeping the regeneration and the growth activity of hard and soft tissues (Mckibbin, 1978; Wangerin & Gropp, 1997). The calotasis is being used more in the distraction osteogenesis in experimental models and clinical applications because the clinical difficulties associates to the first principle (epiphyseal tissues

fragility for the setting of traction mechanical systems and the new bone formation inhibition because the trauma generated for these instruments).

Ilizarov (1990), a russian orthopedics doctor, started his perfecting and applied the DO technique in the superior and inferior endochondral bones members for more than 35 years.

Putti *et al.* (1990) developed a femural extend unilateral device. It consisted in fixed bolts in the proximal and distal portion of the segments and joined for a telescope tube. A distraction mechanism was formed because the continuous and appropriate force was applied by a device (McCarthy *et al.*, 1992).

Other authors had followed this idea, but it was only in the decade of the 50's that Ilizarov (1989a, 1989b) promoted the extend bone by distraction osteogenesis having consistent and previsible results. Ilizarov (1990) showed that the fibrous matrix in the prolonged area is capable to differentiate by itself in lamellar bone tissue. This fact occurred due to the gradual bone callus extend respected the capacity of vessels that nourish the region repair. Since carried through of rhythmic and gradual form the bone extends is possible. Thus, the periosteum and endosteum osteogenesis capacity are related to the formation of a new bone matrix in parallel columns to the extend axis (Querido, 1999). He established the so-called Ilizarov effects: Gradual traction of the tissues creates stress that activates tissue growth and regeneration (law of tension-stress); and the shape and mass of the bone are influenced by the mechanical load and blood supply. Ilizarov (1990) performed tibial distraction in 120 dogs. He observed that a distraction rate of 0.5 mm/day caused a premature consolidation of the bone, an index of 1 mm/day achieved optimum results, and an index of 2 mm/day produced fibrous tissue. With respect to the frequency of distraction, he recorded better outcomes when it was performed 60 times a day compared with 1 or 4 times a day. In other words, he defended the continuous application of tension. He demonstrated that distraction was also produced transversally to the longitudinal axis of the bone, which is of relevance to the distraction of the alveolar ridge.

Ilizarov (1989a) described 2 basic types of distraction: callotasis, or distraction of the fracture callus, and physiologic distraction. They are also described, respectively, as distraction epiphysiolysis (fast traction: 1-1.5 mm/day) and chondrodiastasis (slow traction: 0.5 mm/day). The concept of callotasis is of interest in implant surgery, especially monofocal callotasis for the linear regeneration of tissues. When segmental defects are reconstructed, bifocal

or trifocal distraction is used. This technique was only spread out when Ilizarov presented his studies in a Symposium occurred in New York in the year of 1988 (1989a, 1989b).

Ilizarov had already reported that the ideal frequency of distraction is continuous. In fact, mandibular elongation distractors have been designed for this purpose using hydraulic or spring wire mechanisms. In clinical alveolar distraction studies, some authors attempted to approach this frequency by applying more than 1 distraction procedure per day, distributing the daily amount of distraction between 2 sessions of 0.5 mm or even 3 sessions of 0.3 mm distraction (Ilizarov, 1989b; Rachmiel *et al.*; Snyder *et al.*, 1973).

Snyder *et al.* described the application of the distraction osteogenesis technique in face bones in dogs studies. The apparatus were fixed in external portion of the face and the percutaneous bolts left scars. Michieli & Miotti (1976) described the intra-buccal distractors development in dogs studies. With the success, they proposed an intra-buccal distractors model for human, but it did not arrive to be used. Wangerin & Gropp related a greater patients acceptance in the use of intra-buccal distractors when compared with the extra-buccal ones. These last ones, although to be more steady and malleable, made it difficult for the patients for being discomforted.

McCarthy *et al.* (1992) were the first authors to relate DO application in human. They extend the ascending branch of 4 children through an extra-buccal device having between 18 and 24mm of growth.

Querido & Fan was the first author to use an intra-buccal distractor in human for ortopedicals corrections. In 1996, Martin Chin related be the first author to carry out DO with intra-buccal apparatus in human for alveolar process growth (Feichtinger *et al.*, 2003).

There has been little study of changes in the oral mucosa as a consequence of distraction. In a beagle mandibular elongation model. Cope *et al.* studied in a beagle mandibular elongation model, the mucosa after distraction and at 2, 4, 6, and 8 weeks of consolidation. After distraction, atrophy of the epithelium was observed, with the disappearance of papillae and the loss of intercellular connections in granular and spinous layers, the formation of dilated capillaries was increased in the lamina propria, there was a mild inflammatory infiltrate, and the collagen fibers were distributed parallel to the distraction vector. At 2 weeks of consolidation, the mucosa began to show a more normal appearance: Conjunctive papillae began to appear, the epithelial thickness increased, and the cells recovered a normal architecture, although the inflammatory infiltrate

and low thickness of the horny layer persisted. At 8 weeks, the epithelium had a completely normal appearance, with no scars in any area. There appears to be an initial stretching of the mucosa, which undergoes reorganization in response to this new spatial situation. Later, after a period of consolidation, there seems to be greater cell proliferation in the basal layer.

With the technology and the materials used for the construction and manufacture of odontologic equipments and instruments advanced, more delicate distractor were done. The use indications have grown for the most diverse types of bones deformities.

A singular aspect of the distraction technique is the fact of regeneration be followed by a simultaneous expansion of soft tissues, including vases, nerves, muscles, skin, mucosa, fascia, ligaments, cartilage and periosteum. This adaption process of adjacent soft tissues provoked by tensions generated for the distraction forces is also known as histogenic distraction.

More recently, DO has modified the treatment form of the congenital and acquired craniofaciais defects (Altuna *et al.*, 1995; Holzhauer *et al.*, 1998). With the use of force vectors is possible to get a significant and steady bone remodel, in varied directions, without extensive surgical interventions (Mehra *et al.*, 1999; Rowe *et al.*, 1998). Extra and intra buccal devices have been developed and used for this intention. (Altuna *et al.*; Holzhauer *et al.*) The effects of the distraction vector, the distrator stabilization and the distraction intensity and frequency of the bone corn are variable that have been examined in some studies (Kessler *et al.*, 2002b).

DO have been used successfully in the surgeries of increase bone rim with diverse purposes. One of the important applications occurs in the extensive oral rehabilitations cases where unsatisfactory prosthetic reconstructions are frequent because of the advanced alveolar rim loss and the difficulties in recovering it with enxertia. The DO technique can be used in the rim increase that makes possible implantations arrangement and increase the possibility to get a better cantilever outline in the anodontics areas (Gaggl *et al.*, 2000; Meyer *et al.*, 2001b). In the continuous DO an intramembranous bone regeneration occurs, while in the not continuous distraction process the regeneration follows a standard of chondroid ossification. With a continuous and lesser intensity force application the bone regeneration occurs in a faster speed and presents a lesser consolidation period (Kessler *et al.*, 2002a), and it still has minor possibility of serious inferior alveolar nerve degenerative modifications (Hu *et al.*, 2002).

The period of maintenance of the disjunction device as new bone stabilizing can be vary (Forwood et al., 1998). Some distractors models are being currently produced and evaluated (Grayson et al., 2001; Hu et al.). Studies about compression, twist and shear forces application of the bone prolonged by osteogenesis distraction had been carried out. It was verified that after a period of stabilization between 4 and 8 weeks, after the distraction forces application, the levels of regenerated bone compressibility and twist already met normalized,

although the levels of shear strenght, exactly after 8 weeks still remain reduced.

Until the present moment, the process that the mechanical forces created by the distraction osteogenesis are translated in biological signals able to induce osteogenesis in a perfectly coordinated way is still not clarified. The technician resources of the distraction osteogenesis application proportionate benefits that represent an applicable reality in some areas of dentistry.

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RESUMEN: La distracción osteogénica es una técnica para la inducción de la formación de nuevo hueso entre dos segmentos de un hueso que presenta amplias posibilidades de uso en Odontología. Sin embargo, la información disponible sobre este tema es aún escasa. El objetivo de este artículo es revisar la literatura relacionada con la formación de hueso, mecánicamente inducida por la distracción osteogénica, con el fin de proveer una contribución de acuerdo a este proceso.

PALABRAS CLAVE: La distracción osteogénica, formación ósea; Odontología.

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