Distraction Osteogenesis

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Summary

Distraction osteogenesis is increasingly used for bone lengthening of facial skeleton. Distractors may be intraoral and extraoral. The authors present development of distractors and their use for treatment of facial bones. Procedure may be used for treatment of malformations, syndroms, posttraumatic bone defects and deformities. The advantage of a distractor are a simple and fast procedure, short period of hospitalization, procedure does not require bone grafts and enables simultaneous bone lengthening and lengthening of soft tissues.

Key words: *distraction osteogenesis, development, technique.*

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Introduction

Distraction osteogenesis is a biomechanical process of bone tissue formation, where the distraction forces which act between the bone segments effect the biological potential of the bone by forming a callus of determined length and height. Distraction osteogenesis is preceded by corticotomy or subperiosteal osteotomy and followed by fixation of the distractor on the segments and their gradual lengthening.

History of development

Distraction osteogenesis resulted from various attempts at correction or augmentation of bone structures.

An attempt of skeletal traction was described as long ago as Hippocrates (460-377 B.C.) when traction on long bones was performed by means of rubber straps. In the 18th and 19th centuries correction of deformities by widening of the maxilla ridge by means of expansion arches was described (Fauchard 1728 and Wescott 1859). Kingsley (1866) reported widening the maxilla by extraoral traction. The middle of the 19th century saw the beginning of a period of osteotomy or corticotomy on the corpus (Hullihen 1849, von Eiselberg 1906), on the ascending ramus (Angle 1897, Kostečka 1931, Čupar 1964). Pehr Gadd (1906) described step-wise osteotomy, Blair (1907) vertical osteotomy and Obwegesser (1957) sagittal osteotomy.

In 1905 Codvilla first described distraction as a method for correction of deformities (1). The method was popularised in orthopedic surgery by Ilizarov (1952, 1988, 1992) (2-4). The first attempts of distraction were performed on the mandible of a dog (Snyder 1973) (5), and later on humans (Bell and coworkers 1980) (6).

Types of distractors

Distractors may be extraoral and fixed on the bone segments over the skin (Mc Carthy 1989, 1992), Ortiz Monasterio and Mollina (1993, 1995), Pensler et al (1995), Polley and Figuere (1998) (7-9) and intraoral and placed in the vestibule of the oral cavity (Guerrero 1990, Diner 1993 and 1996, Chin and Toth 1996, Vasquez 1995) (10, 11). Distractors can be designed for the lower jaw, the ramus, and the upper jaw (28) or for specific jaw segments, and according to the direction of the action of distraction forces they can be unidirectional, bidirectional or multidirectional (distraction in length, height and width). As a rule intraoral distractors are unidirectional, while extraoral distractors are today multidirectional. Bell-Epker (1976) and Guerro (1990) described a transversal distractor. A distractor can be fixed on the bone segments ("bone-borne"), teeth ("tooth-borne") or can be combined ("hybrid"). Ortiz Monasterio and coworkers (1997) described simultaneous distraction of the upper and lower jaw (12).

Principle / technique

Following preoperative analyses (orthodontic preparation, cephalometric analysis, analyses of photographs and dental models) surgical intervention can be performed. The bone is approached through an incision of the mucous membrane, approximately 4 cm long, above the intended site for placement of the distractor. The distractor is placed parallel to the occlusal plane when distraction of the horizontal part of a lower jaw is required, or when it is necessary to apply the distractor in accordance with the analysed direction of the action of forces. Following the incision of the periost, the rest of the periost is mobilised. The lingual and buccal corticalis are exposed and the site of the corticotomy or osteotomy is marked, after which the distractor is placed and secured by pins. This is followed by corticotomy or osteotomy and the wound is sutured, while the front part of the distractor with an extension for the screwdriver remains in the vestibule of the oral cavity. After surgery the segments are kept in the existing condition for 7-10 days. Extraoral distractors are placed on the pins, which are percutaneously, i.e. transbuccally placed on the bone segments. The approach to the bone is the same as during application of the intraoral distractor - the place of osteotomy is marked, followed by the placement and fixing of the distractor, the pins of which must be 5 mm away from the place of osteotomy. This is followed by osteotomy and finally suturing of the wound in the oral vestibule. The pins are then shortened for practical reasons to 2 cm above the skin and the distractor is fixed on them.

Extraoral distractors of the new generation (Leibinger) apart from linear, enable angular and transversal lengthening of bone, and this was used in our female patient (Fig. 1, 2). Thus, the horizontal ramus of the lower jaw was lengthened by 54 mm and in the transversal direction by 5 mm. The mandibular angle was increased by 5°. It was impossible to achieve more than this due to problems with mouth opening.

Discussion

Distraction osteogenesis has numerous advantages over osteotomy and osteoplastics. Osteotomy does not enable lengthening of bone for the same amount as distraction osteogenesis. Chin (1996) reported data on lengthening of the mid-face by 30 mm. Intraoral distractors can lengthen bone up to 28 mm (Martin - 20 mm, Medicon - 25 mm, Leibinger - 28 mm). Osteotomy frequently requires the use of bone transplants (Block 1996) (13). Fistulae and resorption of bone transplants are not infrequent (Jensen 1990, Mc Intosh 1985) (14) and delayed healing and noncoalescence. Complications are also possible in the areas where the bone transplants are taken (bleeding, infection, marked scar, pneumothorax); (Mc Intosh 1985, Laurie 1984) (15). Osteotomy and osteoplastics also frequently require intermaxillary fixation, which in cases of distraction osteogenesis is unnecessary (Polley 1998).

Chin (1996), like Tavakoli and coworkers (1998), (16, 17) reported that distraction in the mid-face area of 10 to 25 mm is accompanied by marked tension of the soft česti? and that tension of the soft česti? increases exponentially with distraction above these values. Like Ilizarov (3) he considers that childhood bone tissue response to distraction is essentially different. Thus, distraction can be started immediately postoperatively, retention is of shorter duration and greater distraction is possible on a larger scale.

Numerous protocols exist on distraction osteogenesis. According to Ilizarov (1952) after application

of the distractor the period of latency lasts for 5 to 7 days, and only after that period can the distraction process be started; for which he recommended 4 x 0.25 mm per day. Chin (1996) considers that for distraction osteogenesis in the correction of childhood craniofacial deformities it is possible to avoid the latency period (Chin, Bryant, Tooth 1996) (10), while Mc Carthy (1989) is of the opinion that distraction should be carried out 2 x 0.5 mm per day, Mollina and Ortiz Monasterio (1995) recommend 1 x 1 mm per day. In the case of the female patient in this study bone was lengthened 1 mm per day.

The indication spectrum includes craniofacial deformities (Crouzon syndrome, Apert's syndrome (9), 18p - syndrome), hemifacial microsomia, Goldenhar's syndrome, hypoplasia of the lower third of a face (Pierre-Robin syndrome, Treacher-Collins syndrome) (18-20), hypoplasia of the maxilla in cleft lip and palate, posttraumatic deformities of the middle and lower third of the face, ankylosis of temporomandibular joints (21) and hypoplasia of the ramus, due to damaged ossification centres, bone defects after injury (22), etc. Sleep apnea obstruction (23) and other obstructions of the upper respiratory tract as a consequence of hypopoplasia of the maxilla can be an indication for distraction osteogenesis (24, 25).

The indication spectrum is increasingly being extended to include dentofacial deformities and augmentation of the jaw ridge (26), and also conditions following tumour surgery and bone resection.

For placement of a distractor the direction of distraction and their vectors must be analysed . The process of distraction osteogenesis includes a period of latency, period of distraction and a period of retention, i.e. consolidation. The period of latency represents the period from osteotomy to the start of the distraction process. This period is necessary for the formation of the primary callus. This is followed by the process of distraction, when the bone segments are moved apart by a shaped screwdriver, in accordance with previously agreed protocol, with lengthening of 0.5 to 1.5 mm per day until the planned bone lengthening has been achieved. Thereafter follows a period of preserving the achieved condition for a period of approximately 8 weeks (McCarthy 8-10 weeks) so that mature bone tissue is formed from the primary callus. The distractors are then removed.

The distraction period includes a period of callus formation and lengthening up to the planned value. Following which the process is halted until the callus has matured into bone tissue (period of retention, namely consolidation). The distractor is then removed. Karp and Mc Carthy (1992) (27) reported that histologically four zones can be found in the area of the bone distraction: a central connective zone with collagenous fibres situated parallel to the axis of the lengthened bone, a transitional zone with osteoblasts, a remodelling zone with osteoclasts and on the periphery a zone of mature bone tissue. Komuro (1994) (28) and co-workers, divided the healing process into three zones on the basis of X-rays; two sclerotic zones on the periphery and a centrally located transparent zone.

Intraoral distractors require patient co-operation and consequently, as a rule, they are reserved for children above 6 years of age (29). Intraoral distractors are unidirectional (linear), are difficult to fix, difficult to remove and difficult to manipulate. Extraoral distractors lead to scars on the skin at the place where the pin is fixed. During the process of application they can injure the marginal branch of the facial nerve. The following injuries have been described of the: n. alveolaris inferior (Block 1993) (29), n. infraorbitalis, the germ or tooth root lesions, local inflammation and sinusitis, including sinus empyema, delayed ossification (29) and pain in the temporomandibular joints (Kocabalkan 1995, Bagatin 1999) (19, 20). Cases of bradycardia have been reported during distraction, which were successfully treated by atropine for activation of the occulocardial reflex tract in mid-face distraction (Chin, Tooth 1996) (10). Osteoporosis and allergy to metal are absolute contraindications for distraction osteogenesis (Vasquez, Diner, 1994) (11).

Conclusion

Distraction osteogenesis is increasingly used for correction of craniomaxillofacial deformities. Apart from bone lengthening it also has a secondary effect on the lengthening of soft tissue. Distraction osteogenesis enables correction of deformities earlier than osteotomy. The placement of a distractor is on the whole quite simple, complications are rare and the procedure does not require bone grafts.

Due to the above numerous advantages broadening of the indicational spectrum can be anticipated.