STRUCTURAL MODIFICATIONS OF THE MANDIBULAR CONDYLES INDUCED BY DISTRACTION OSTEOGENESIS

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INTRODUCTION

Distraction osteogenesis is a surgical technique that allows bone lengthening through a biological process of new bone formation between two vascularized bone surfaces, which have been surgically sectioned and gradually separated, in a controlled way. This procedure is performed in patients with craniofacial malformations, of either acquired or congenital etiology, such as mandibular hypoplasia, facial asymmetry and hemifacial microsomia. When compared with conventional orthognathic surgery, distraction osteogenesis allows a more gradual increase on the mandibular length making the treatment less invasive. Despite the growing use of this technique, its impact on mandibular condyles has not been sufficiently studied and understood.

AIM

Study the effects produced by two different rates of distraction in beagle dogs' mandibular condyles by using Cone Beam Computed Tomography.

METHODS

A) EXPERIMENTAL MODEL

An experimental model was developed, using the dog as the laboratory animal (authorization nº 0420/000/000/2012). Ten beagle dogs were used (*Canis familiaris*), of pure origin, born and raised for research purposes. Initially, the sample was divided by randomization methodology in two groups:

- **Control Group** – Composed by three dogs that were not submitted to distraction .
- **Test Group** – Formed by seven dogs that underwent to distraction. The distraction protocol included five stages that can be seen in image 1.

In each animal the left and right hemimandibles were considered. The protocol of the study groups can be seen in table I.

Table I. Protocol of the Study Groups

Groups	Designation	Hemimandibles (Nº)	Procedure
Control	A	6	
Test	B	7 (Right)	10mm: Distraction rate of 0.5mm, twice a day
	C	7 (Left)	10mm: Distraction rate of 1mm once a day

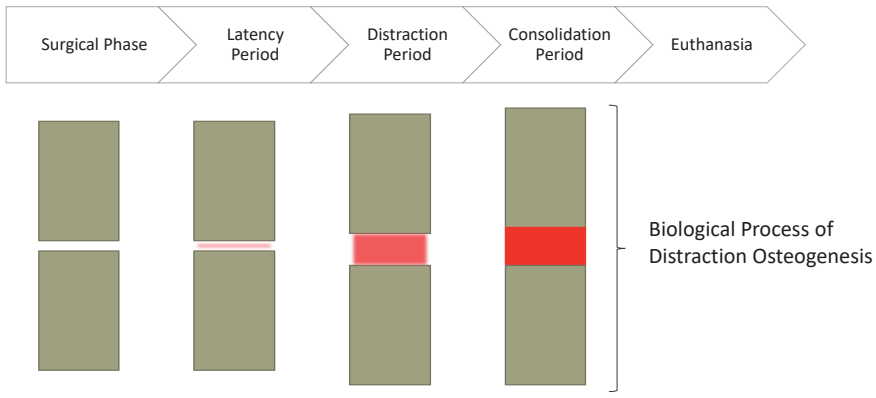
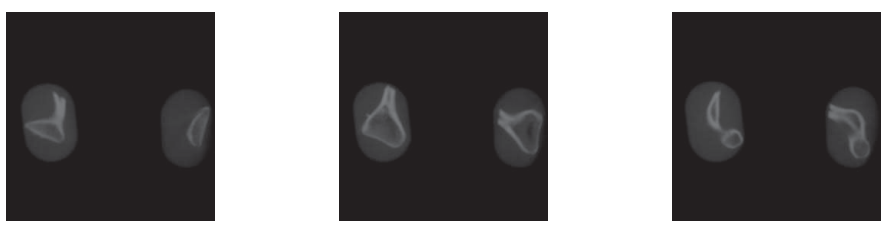


Figure 1. Surgical Protocol of Distraction Osteogenesis and its Biological Process.

B) CONDYLES ANALYSIS

The condyles were fixed in an acrylic platform and the CBCT images were performed in this set (Figs. 2, 3 and 4).



Figures 2,3, 4. CBCT images of used mandibular Condyles

The analysis of the CBCT images of the condyles was made using Matlab (Mathworks©).

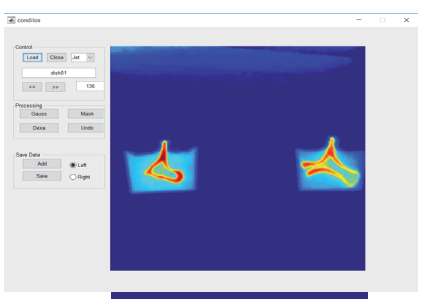


Figure 5. To compute the average of the values within the condyle it is necessary to segment the condyle from the acrylic part. In order to it, a simple algorithm was implemented where a threshold value is computed to separate acrylic from the condyle.

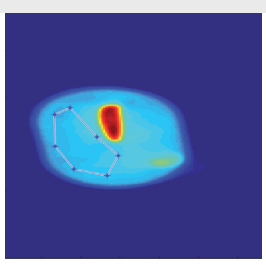


Figure 6. Definition of a region of interest (ROI) within the acrylic part that permit to compute the average value which is then used to know which values are from the condyle as they have to be higher than the threshold.

RESULTS

The following chart depicts the distribution for values obtained for the two condyles' images.

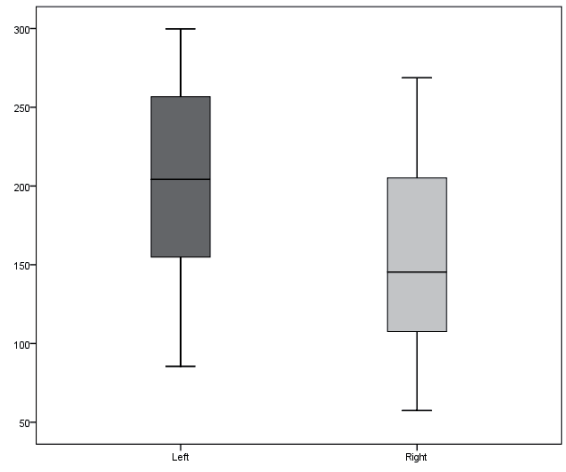


Table II. ObtainedMean Values

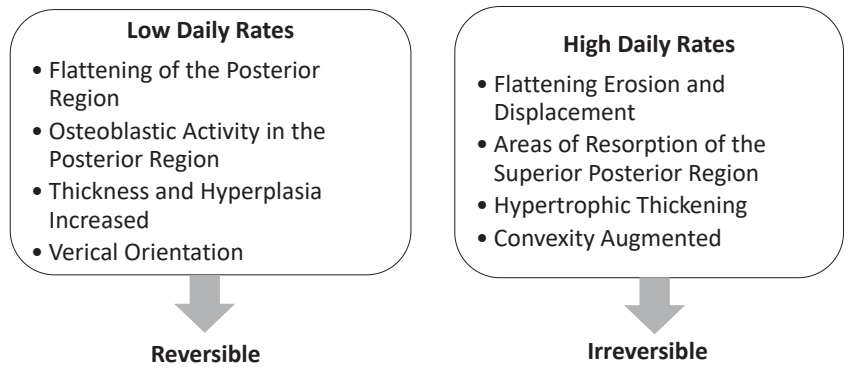
Left Condyles	197.6 (±70.0)
Right Condyles	159.3 (±72.4)

The difference between the mean CBCT value for the two groups is not statistical meaningful ($t(24) = 1.369; p = 0.184$).

DISCUSSION

The goal of the present study was to understand if there was any structural modification on the mandibular condyles resulting from distraction. Despite the lack of statistical meaning it worths mention that the mean value is higher in the group submitted to the slowest distraction rate, suggesting that bone consolidation, by means of bone mineral density, improves inversely to the distraction rate.

According to the actual literature, it is known that distraction may induce adaptive changes in the temporomandibular joint, which can be influenced by increased daily rates and total activation length of distraction osteogenesis.



For the most part, the literature states that increased daily distraction rates, increased tensions or increased lengths may cause irreversible injury and degenerative changes in the cartilage. On the other hand, lower distraction rates may lead to changes in the condyles, but with reversible character. However, the limit between physiologic and increased levels has not been defined yet. As regards to the conducted study, where CBCT images of dogs' mandibular condyles were analyzed, the results were the predicted ones.

The results showed that the left side has more bone mineral density than the right one, despite the absence of statistically significant diferences between groups.

Hence, can be concluded that bone consolidation, by means of bone mineral density, increases inversely to the distraction rate. The results obtained are in agreement with the literature, as regards to the rhythm of distraction.

CONCLUSION

Distraction Osteogenesis may induce adaptive changes in the mandibular condyles, which can be influenced by increased daily rates and total activation length of distraction.

Besides this, the experimental study that was made in this work showed that bone consolidation (by means of bone mineral density) increases inversely to the distraction rate.

Concluding, future studies are needed to assess structural modification of the condyles, resulting from distraction osteogenesis.

REFERENCES

Ahn SY, Kim SG. Condylar cartilaginous changes after mandibular distraction osteogenesis in rabbits. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011; 112:416-422.
Zou S, Hu J, Wang D, Li J, Tang Z. Changes in the temporomandibular joint after mandibular lengthening with different rates of distraction. Int J Adult Orthod Orthognath Surj. 2001; 16:221-225.
Stelnicki EJ, Stucki-McCormick SU, Rowe N, McCarthy JG. Remodeling of the temporomandibular joint following mandibular distraction osteogenesis in the transverse dimension. Plast Reconstr Surg 2001; 107:647–658.
Rafferty KL, Sun Z, Egbert M, Bakko DW, Herring SW. Changes in growth and morphology of the condyle following mandibular distraction in minipigs: Overloading or underloading? Arch Oral Biol. 2007; 52(10): 967-976.
Sant 'anna EF, Gomez DF, Polley JW, Sumner RD, Williams JM, Figueroa AA, Bolognese AM. Histological Evaluation of the Temporomandibular Joint After Bilateral Vertical Ramus Mandibular Distraction in a Canine Model. J Craniofac Surg. 2007; 18:155-162.
Herford AS, Hoffman R, Demirdji S, Boyne PJ, Caruso JM, Leggitt VL. A comparison of synovial fluid pressure after immediate versus gradual mandibular advancement in the miniature pig. J Oral Maxillofac Surg. 2005; 775-785.
Kim SG, Park JC, Kang DW, Kim BO, Yoon JH, Cho SI, et al. Correlation of immunohistochemical characteristics of the craniomandibular joint with the degree of mandibular lengthening in rabbits. J Oral Maxillofac Surg. 2003; 61:1189-1197.
Kim SG, Ha JW, Park JC. Histological changes in the temporomandibular joint in rabbits depending on the extent of mandibular lengthening by osteodistraction. Br J Oral Maxillofac Surg. 2004; 42: 559-565.
Thurmüller P, Troulis MJ, Rosenberg A, Chuang SK, Kaban LB. Microscopic changes in the condyle and disc in response to distraction osteogenesis of the minipig mandible. J Oral Maxillofac Surg. 2006; 64:249-258.
Kruse-Lösler B, Meyer U, Flören C, Joos U. Influence of distraction rates on the temporomandibular joint position and cartilage morphology in a rabbit model of mandibular lengthening. J Oral Maxillofac Surg. 2001; 59:1452-1459.
Mihmanli A, Dolanmaz D, Tüz H, Pampu A, Dönmez HH. Histomorphometric examination of long-term changes in temporomandibular joints after mandibular lengthening by distraction osteogenesis in rabbits. Oral Surg Oral Med Oral Pathol Oral Radiol. 2012; 113:600-603.
Sant'Anna EF, Gomez DF, Sumner DR, Williams JM, Figueroa AA, Ostric SA, Theodoru S, Polley JW. Micro-
Computed Tomography Evaluation of the Glenoid Fossa and Mandibular Condyle Bone After Bilateral Vertical Ramus Mandibular Distraction in a Canine Model. J Craniofac Surg. 2006; 17(1):111-9.
Thurmüller P, Troulis MJ, Rosenberg A, Kaban LB. Changes in the Condyle and Disc in Response to Distraction Osteogenesis of the Minipig Mandible. J Oral Maxillofac Surg. 2002; 60:1327-1333.
Landes CA, Laudemann K, Sader R, Mack M. Prospective changes to condylar position in symphuseal distraction osteogenesis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008; 106:163-72.