EFFECTS OF RHYTHM OF DISTRACTION OSTEOGENESIS ON SAGITTAL MANDIBULAR LENGTHENING

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INTRODUCTION

The distraction osteogenesis is a surgical orthopedic technic used to lengthen bones. It is the regeneration of new bone between 2 vascularized bone surfaces that are gradually separated by a mechanical device[1,2]. Distraction osteogenesis (DO) was first described by the Italian Alessandro Codivilla[3], and the first experimental report of bone elongation in the facial was reported by Snyder in 1973. The biological and biomechanical principles that allowed its large-scale application in orthopedics, are due to experimental and clinical studies developed by the Russian Graviil Ilizarov[4]. In 1992 McCarthy[5] used the DO to lengthen the jaw of a patient with hemifacial microsomia and, since then, this technique has been increasingly accepted in the treatment of craniofacial deformities.

There are a variety of factors such as the latency period appropriated for the formation of the reparation bone callus, the speed and rhythm of distraction and the proper consolidation after the distraction, which decisively influence the quality and amount of bone produced during the mandibular lengthening[6,7]. The influence of these factors can manifest itself not only during the process of distraction but also before or during surgery and subsequent consolidation. Although the rhythm or rate of distraction can influence the whole process of DO, there are few experimental studies on the effect of this parameter on the quality and quantity of the new bone formation.

The objective of this study is to evaluate the effect of two different rates of distraction in new bone formation during DO in canine's jaws with tooth-anchored distractors.

Fig. 1 – Occlusal relationship before DO

Fig. 2 – Occlusal relationship after DO

Fig.3 - Latency period

Fig.4 - Beginning DO

Fig.5 – 2 weeks after DO

Fig.6 – 8 weeks after DO

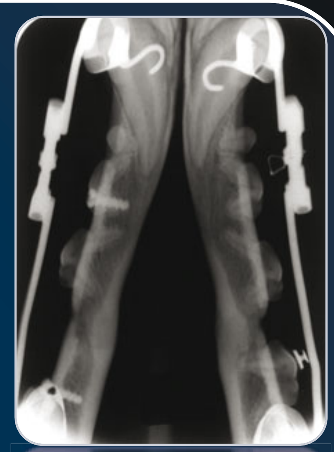


Fig.7 - 10 weeks after DO

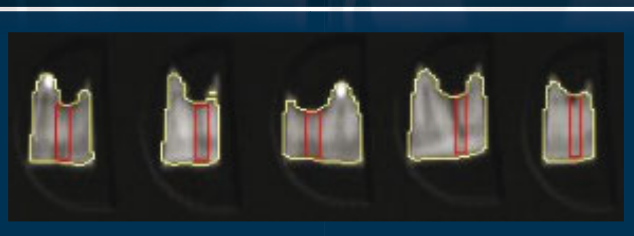


Fig. 8 – DEXA scan with regions of interest in red

Fig. 9 – Histolgical samples for processing

MATERIALS AND METHODS

The sample group consisted of 10 male beagle dogs with 1 year old, weighing 15-18kg. The animals chosen for the protocol, underwent an osteotomy between the third and fourth premolar. Then was cemented one distractor in each hemi-mandible with maximum dilation of 11mm that were previously manufactured in the laboratory. Seven days after the surgery (latency period), was initiated the process of increasing the mandibular length daily and continuously for 10 days.

We applied three different protocols: **Group A:** 6 hemi-mandibles did not suffer any surgical procedure, remaining as a control group. **Group B:** 7 hemi-mandibles were subjected to a distraction of 0.5 mm, twice a day . **Group C:** 7 hemi-mandibles were subjected to a daily single distraction of 1mm.

After the distraction period, all devices were properly locked and followed by a consolidation period of 12 weeks *(Fig.1, Fig.2)*.

In order to control the process of osteogenesis, an occlusal and lateral radiographs were taken before the surgery and weekly until the day of euthanasia *(Fig.3, Fig.4, Fig.5, Fig.6 e Fig.7)*. At the end of the experimental period samples were sent to the Hard Tissue Laboratory of FMUC and then prepared for densitometric, histologic and histomorphometric evaluations *(Fig.8)*.

The evaluation by dual energy bone densitometry (DEXA - Dual X-ray absorptiometry) was made laterally to the hemi-mandibles submitted to distraction (Groups B and C) and to the ones not intervened (Group A) using the densitometer *Hologic QDR 4500 - Hologic, Inc., Waltham, MA*, with double peak voltage of 140Kv and 100Kv, current of 2.5 mA and 0.5 mm pixel size. All hemi-mandibles were positioned in the same way (with the lingual surface down), and all DEXA scans were performed by the same technician. In the protocol groups was outlined a rectangle placed in the area of bone distraction *(Fig.9)*. The rectangle has the same area for all the samples. In each sample of the control group was designed a rectangle, positioned in the interdental space corresponding to the site of incision and distraction of the experimental groups. Posteriorly the following elements were sent for statistical analysis: scanned area, bone mineral content-BMC and bone mineral density-BMD. Was performed the Mann-Whitney test with a confidence interval of 95%. To check which of the procedures had better results was performed the Kruskal-Wallis test, and thus determine whether or not statistically exists significant differences between groups. It was also carried out an analysis based on the mean and coefficients of variation of BMC and BMD and in groups B and C was carried out a Levene's test upon the coefficient of variation.

RESULTS

In tables *(Tab.1, Tab.2 and Tab.3)* We can find the corresponding results and descriptive statisticsCI 95% (0.60; 0.89), and in the groups of distraction is 0.6557g, CI 95% (0.55; 0.76). There is no significant statistical differences between the medians of the two groups (U= 29.0; Z = -1.075; p =0.283). The average value of BMD in the control group is 0.6808 g/cm2, IC95% (0.63; 0.73), and in the groups of distraction is 0.6354 g/cm2, CI 95% (0.58; 0.69). There is no significant statistical differences between the medians of the two groups (U= 30.0; Z = -0.990; p =0.353). Comparing the different protocol groups, there is no significant statistical differences (χ _KW ^ 2 (2) = 1.322, p = 0.516) for the BMC and also (χ _KW ^ 2 (2) = 0.855, p = 0652) relative to BMD. It is observed that there are significant statistical differences (F(1,12) = 5.212, p = 0.041) between the coefficient of variation in groups B and C.

DISCUSSION

Bone densitometry using dual energy is a safe, low-radiation method that effectively study the bone mineral content (BMC) and bone mineral density (BMD) in the distraction zone[8]. With this method it is possible to evaluate the stiffness of new bone tissue and thus establish the ideal time to stop the process and remove the DO distractor[9].

Generally the decision to remove the distractor is done according to clinical criteria like radiographic exams and the consolidation period. Several studies have shown that adding the evaluation by densitometry to these clinical criteria, decreases 5 to 10 times the likelihood of fracture or deflection of the new bone formation after removing the distractor[10].

In this study it was found that there are no differences in bone mineral content and bone mineral density between the newly formed bones on the groups that underwent DO and the newly formed bone in the control group. There were also no differences between the groups that underwent the DO. There are, however, less variation in BMD and BMC in the group of bi-daily activation, suggesting that although the rate of elongation 1mm/day have produced good results, these may be even better if we increase the number of activations to perform this elongation (rhythm of distraction).

Ilizarov demonstrated that elongation of 1mm/day is the rhythm of distraction that produces better results in the process of DO. Subsequent studies demonstrated that a rhythm below 1mm/day led to premature bone union, and over 1mm/day was detrimental to the healing mechanism, favoring the invasion of fibrous tissue in the zone of distraction[11].

Table 1. Averages Comparison between the Control Group and Group of Continuous Distraction

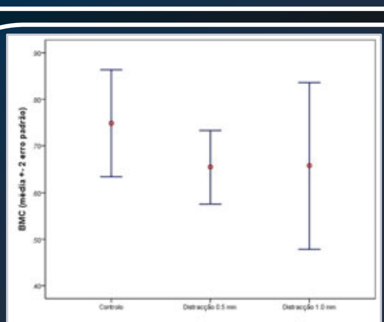
	Group A		Group B				
	Mean	CV(%)	Mean	CV(%)	*U*	*Z*	*p*
BMC(g)	0.7483	18,85	0.6543	15.86	29.0	1.075	0.283
BMD(g/cm2)	0.6808	7.07	0.6479	10.35	30.0	0.990	0.353

Table 2. Averages Comparison between Control Group and Group of Single Distraction

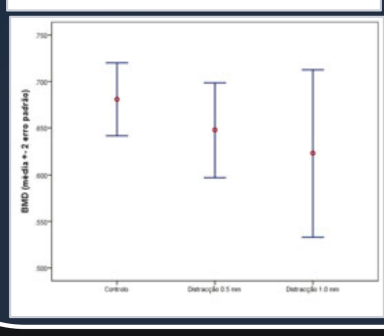
	Group A		Group C				
	Mean	CV(%)	Mean	CV(%)	*U*	*Z*	*p*
BMC(g)	0.7483	18,85	0.6571	35.99	29.0	1.075	0.283
BMD(g/cm2)	0.6808	7.07	0.6229	19.07	30.0	0.990	0.353

Table 3. Averages Comparison Between groups that underwent DO.

	Group B		Group C			
	Mean	CV(%)	Mean	CV(%)	*χ_KW^2(2)*	*p*
BMC(g)	0.6543	15.86	0.6571	35.99	1.322	0.516
BMD(g/cm2)	0.6479	10.35	0.6229	19.07	0.855	0.652



Graph 1. Marginal means BMC



Graph 2. Marginal means BMD

CONCLUSION

The rhythm of distraction, which seems to have influenced the coefficient of variation in the groups submitted to distraction, complies with the observed in other studies that have demonstrated a direct relationship between the increase in the rate of distraction and acceleration in the process of bone regeneration[12]. It seems clear that the continuous distraction is more favorable, rather than a single activation per day, confirming the principle of the law of Tension-Stress of Gravill Ilizarov.

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