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Orthodontic tooth movement with and without corticotomy – A study realized on animal model

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ABSTRACT

Orthodontic treatment of dento-maxillary anomalies is a common therapeutic intervention, with a growing number of pediatric and adult patients requiring it [1]. The raising understanding of the need for this treatment option has led to a shift in the addressability of various social groups, leading to an increase in adult patients' interest [2]. Orthodontic treatment in adult patient is more dificult because the bone remodeling is hard to do and thereis not growing process.
Cortiotomy consists of milling the alveolar bone, the vestibular board, in order to create small labor in which the dental displacement following the application of orthodontic force will be faster. The corticotomy is performed in local anesthesia, with bone cutters, under continuous cooling with saline. Orthodontic treatment in adult patient is more difficult because the bone remodeling is hard to do and thereis not growing process [3]. Filho et al. said that the introduction of this technique of corticotomy makes it possible to solve complex cases while providing an alternative to the classical approach, eliminating a number of inventients, such as dental extractions [4].
Despite the many benefits it can bring when it is integrated into orthodontic therapy to correct various dento-maxillary changes, the corticotomy is still regarded with some reluctance by orthodontists. Reitan et al. (2015) consider that the main reason is that the intervention is expensive and some consider it invasive [5]. In a similar study, Bos et al. (2005) points out that even for patients, the high costs of such an intervention can lead to its refusal, with the risk of obtaining results at the end of less satisfactory orthodontic treatment [1].
Dab et al. (2007) states that there is a direct link between the degree of dental displacement induced by the corticotomy and the type of dento-maxillary anomaly that needs to be corrected, but also the time of orthodontic treatment in which the surgery is performed [6]. Further experimental studies are also needed to understand in more detail the biological mechanisms and transformations that occur at the intervention level.

Keywords: corticotomy, bone, acceleration, orthodontic treatment, dental movement

INTRODUCTION

The amplitude of the dental displacement, the technique used, the therapeutic objectives, and the patient's compliance all determine the timeframe of an orthodontic treatment [7]. Orthodontic therapy, on the other hand, has a number of challenges that might also make some patients more unwilling to undertake it. According to studies, the most prevalent reason for such treatment refusal is the length of time required to complete it, which some patients believe to be excessive [3,4]. According to Kale et al., the typical orthodontic treatment length is two years, which is a period of time that patients, as well as their parents, feel to be unreasonable [8].

Various procedures have been performed over time to try to accelerate tooth movement. The de-

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gree of tooth displacement may vary depending on the local or systemic use of certain medications, according to Kale et al. [8], a finding also supported by Tyrovola et al. (in their research) [9]. Many factors influence the degree of tooth displacement, including root length and alveolar bone height . The ability of the teeth to move varies from individual to individual [10].

Although animal studies have shown significant benefits additional research is needed to confirm and prove the effectiveness of such approaches in current medical practice. Physical stimuli [in the form of vibrations) were also used, which were more easily tolerated by patients than other procedures due to their less invasive nature In addition, when the orthodontic force is combined with vibratory stimulation, a higher degree of displacement is observed in laboratory animals [9].

A surgical approach, namely corticotomy, is one of the most well-known procedures when it comes to a more significant tooth displacement. Both clinical and laboratory animal research have proven that this method is efficient [10] Selective alveolar decortication, surgically facilitated osteogenic orthodontics, or periodontal accelerated osteogenic orthodontics are all terms for a series of linear or punctiform perforations of the cortex around the teeth to be displaced [11]. The Wilcko brothers introduced the concept of corticotomy with bone augmentation in 2001, ensuring a favorable post-intervention periodontal tissue evolution. Bone augmentation in the direction of tooth movement, they assume, corrects existing bone defects or reduces the development of new defects as a result of orthodontic tooth displacement [12].

The aim of this study was to compare the rate of tooth displacement associated with conventional orthodontic biomechanics to a contemporary corticotomy approach.

MATERIAL AND METHODS

The research was conducted on a group of eight adult Beagle dogs of medium size at the Faculty of Veterinary Medicine in Bucharest. This breed's dogs are medium-sized, well-proportioned, and have a curvy, graceful body line, a compact and strong trunk, and short, thick, and rough-haired fur. The eight dogs were separated into two groups: the control group, which received traditional orthodontic therapy, and the study group, which had a corticotomy. The study was approved by the Ethics Comittee of Faculty of Veterinary Medicine Bucharest.

The extraction of the second mandibular premolars on both hemiarcades was performed under general anesthesia in the first phase of the experiment in order to achieve the mesialization of the third premolars (Figures 1a and Figure 2a).

FIGURE 1a. Intraoral image before extraction

FIGURE 2a. Intraoral image after extraction of the second premolar

Four weeks after the extraction of the second premolars, highlighted by the wound healing, a fixed device was mounted on the mandibular arch, with cemented bands on canine and the third premolar, with a rectangular 0.19 X 0.25 stainless steel archwire, ligated with wire ligatures. For the horizontal movement of the third premolar, a nickel-titanium closing spring was applied, by activating which the premolar will mesialize (Figure 3a). Closing springs were introduced in orthodontic medical practice in 1931, being used to initiate various dental movements. They represent, orthodontic triggering elements in helical form.

FIGURE 3a. The orthodontic appliance fixed on canine and third premolar

In the other 4 dogs, after the insertion of the fixed device, the corticotomy technique was applied. This consisted of the incision of a trapezoidal flap, under general anesthesia (Figure 4a). Then two vertical incision lines were made, mesial and distal to the third premolar that had to be moved along the arch. Subsequently, the two vertical lines were joined with a horizontal initiation, made 2-3 mm above the apex (Figure 5a). The 1-2 mm thick corticotomy incisions were made with a bone burr, under saline irrigation, to avoid heating the bone cortex. Finally, the flaps were repositioned and resorbable sutures were applied (Figure 6a).

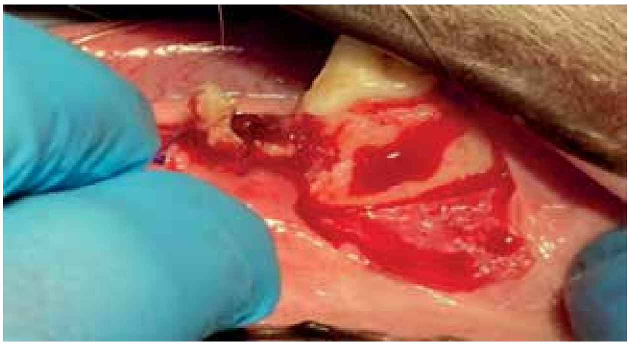

FIGURE 4a. Full trapezoidal flap

FIGURE 5a. The corticotomy lines

FIGURE 6a. The suture of the flap

Following that, the degree of dental displacement between the distal face of the third premolar and the mesial face of the canine was measured using an electronic subler, with measurements taken at the time of device application (T0), one week after corticotomy (T1), two weeks after corticotomy (T2), and four weeks after corticotomy (T3), in both the control and corticotomy groups.

RESULTS

The results of the measurements performed with the help of the electronic caliper showed significant differences in terms of the rate of tooth displacement in the control group and in the experimental group. Thus, in one of the subjects in the control group, the values recorded were 34.49 mm at T0, 33.95 mm at T1 (Figure 1b), 33.29 mm at T2 (Figure 3b) and 33.10 mm at T4 (Figure 5b). On the other hand, the value measured in one of the dogs in the experimental group was 35.95 mm at T0, 35.30 mm at T1 (Figure 2b), 34.34 mm at T2 (Figure 4b) and 33.52 mm (Figure 6b).

FIGURE 1b. The distance canine-third premolar at T1 (control group)

FIGURE 2b. The distance canine-third premolar at T1 (experimental group)

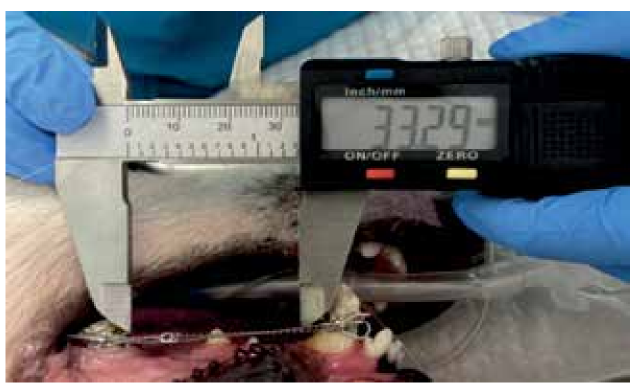

FIGURE 3b. The distance canine-third premolar at T2 (control group)

FIGURE 4b. The distance canine-third premolar at T1 (experimental group)

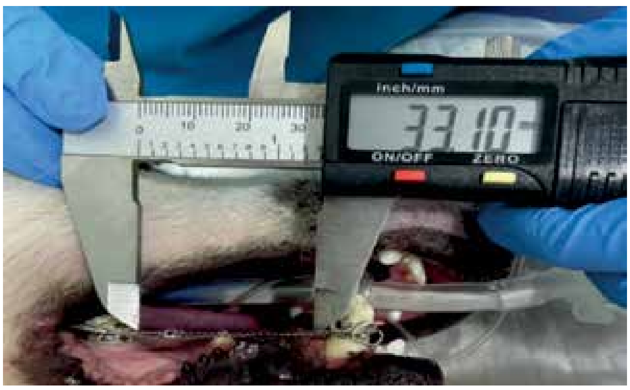

FIGURE 5b. The distance canine-third premolar at T4 (control group)

FIGURE 6b. The distance canine-third premolar at T1 (experimental group)

According to the data recorded in the weekly measurements (Table 1 and Table 2), in the experimental group the lowest dental displacement was observed from T0 to T1: 0.65 mm, 0.54 mm, 0.40 mm and 0.75 mm. In the control group in one of the subjects, the lowest value was registered from T1 to T2, respectively 0.05 mm.

When the orthodontic force was associated with the corticotomy intervention, dental displacement appeared in all subjects in that group, while in the first group in one of the study animals the distance between canine and third premolar remained unchanged, respectively 34.50 mm.

TABLE 1. Distance canine-third premolar measured in the control group at T0, T1, T2, T4

Time of measurements	Distance measured from C to PM3 (mm)			
	Animal 1	Animal 2	Animal 3	Animal 4
T0	34.49	34.50	36.05	36.08
T1	33.95	34.50	36.05	36.02
T2	33.29	34.50	36.03	36.02
T4	33.10	34.50	36.03	36.00

TABLE 2. Distance canine-third premolar measured in the study group at T0, T1, T2, T4

Time of measurements	Distance measured from C to PM3 (mm)			
	Animal 1	Animal 2	Animal 3	Animal 4
T0	35.95	36.10	35.00	35.90
T1	35.30	35.70	34.50	35.85
T2	34.34	35.10	33.85	35.70
T4	33.52	34.00	32.55	35.25

The degree of tooth displacement increased progressively from one week to the next in the case of subjects with corticotomy, according to the measurements taken on the two groups. One of the subjects in the control group had a change in the canine-third premolar distance from T0 to T1 (0.54 mm) and from T1 to T2 (0.54 mm) (0.6 mm). The displacement from T0 to T1 (0.06 mm) in another animal remained constant from T1 to T2, while the measured value at T4 was 0.02 mm lower. The most pronounced dental displacement was 2.45 mm at the second batch level, a significant difference from the first batch's maximum value of 1.39 mm.

When analyzing the evolution of the dental displacement rate between consecutive measurements, significant changes were observed in the experimental group, where the notable values were obtained in the range T2 - T4, respectively 1.1 mm, 1.3 mm and 0.45 mm. In only one subject from the experimental group, the highest value was measured in the range T1 - T2, namely 0.96mm, a situation corresponding to the control group, where in 2 of the study animals the highest values were recorded in the same range T1 - T2, respectively 0.66 mm and 0.02 mm.

At the level of the group where only orthodontic force was applied, the average displacement was 0.37 mm, a value almost 5 times lower than that obtained in the group with corticotomy: 1.90 mm.

DISCUSSIONS

The complexity of cases requiring a specialized therapeutic approach has increased as the addressability of patients to orthodontic treatments has increased, resulting in the emergence of individualized orthodontic devices and maneuvers best suited to the clinical context to finally achieve the desired result for both patients, but also a functional and biological outcome.

The tooth's first reaction to a stimulus is almost immediate (on the scale of fractions of a second) and represents the tooth's movement inside the viscoelastic matrix of the periodontal ligament [13]. Despite all of this progress in the field of orthodontics, the biggest disadvantage of orthodontic therapy, as stated by both patients and professionals, is the increased time required to complete it [1,2].

Wilcko et al. suggested an alternative approach to a surgical technique of accelerating tooth movement a decade ago. Despite the fact that corticotomy has been described in the literature for a long time, he believes that increased tooth displacement is caused by a phenomenon of local metabolic acceleration in the area where the procedure is performed [12]. It has 3 stages, similar to the healing process of a normal fracture: the reactive phase, the repair phase, and the stage when bone remodeling occurs. However, compared to physiological repair processes, this acceleration would result in much faster healing [up to ten times faster) [13].

It begins a few days after the intervention, peaks at 4-8 weeks, and then turns toward a recovery period that lasts a few months [14]. This finding has caused a series of investigations in this area, with the aim of confirming that metabolic acceleration is the biological basis for rapid tooth movement [15]. These metabolic acceleration mechanisms have been proven in studies to lead to a decrease in bone mineral density, which can lead to transitory local osteopenia. This is why, during the bone remodeling process, when a mechanical force is applied to the dental structures through an orthodontic device, they will move more quickly [15,16].

Several experimental animal studies have been conducted over time to confirm the validity of this hypothesis. However, a number of similarities in bone support are required in terms of density, quality, resorption rate, and bone apposition in order to be comparable to studies in patients [17]. Human bone is shown to be similar to canine bone, according to research [18]. Despite considerable differences in bone metabolic rate, which is faster in dogs, the canine model is preferred for studies of bone marrow structure [18]

Cho et al. conducted an experiment on two beagle dogs that had their second premolars removed, and after four weeks, they performed a flap with 12 perforations in the vestibular and lingual cortex, followed by a coil-spring traction force. After 8 weeks, tooth displacement was nearly 4 times more in the maxillary area than in the control area, and about 2 times faster in the mandibular area [19].

Iino et al. conducted a similar study, but with a bigger experimental sample and a 16-week interval between the first and second interventions. The movement on the corticotomy side was double that of the control half after roughly 4 weeks, although it was observed that the movement was quicker in the first 2 weeks, after which the differences were insignificant [20].

In another study on the same topic, Mostafa et al. performed corticotomy surgery in the same session as premolar extractions, using skeletal anchorage for distalization. A distalizing force was then applied for 5 weeks. In this study, too, the degree of displacement was almost double on the test side compared to the control side, but after the 4th week the differences were no longer significant [18].

The degree of tooth displacement was greater when the orthodontic force was associated with corticotomy in the current study, which was consistent with other similar research [21]. There was some tooth displacement on both sides during the first week of the research. This can be explained by the fact that experts believe localized accelerating phenomena are caused by simple orthodontic movement of the teeth [22]. The teeth on the side where the corticotomy was performed, on the other hand, moved nearly twice as much at the end of the first week. Cho et al. and Iino et al. made the same observation in their research [19,20]. During the four weeks of this research, the degree of tooth displacement on the test side continued to increase, but on the side where only the extraction were performed, the variations between two successive measurements were significantly smaller. This is because the local metabolic reaction rises in direct proportion to the stimulus provided in that area, according to Dutra [23,24].

Corticotomy, according to the literature in this field, can considerably accelerate the rate of tooth displacement. Studies, on the other hand, say that they only have a 1-2 month window of activity following the intervention [25,26]. Given that the canine model's rate of bone metabolism is 1.5 - 2 times quicker than humans', we may estimate that the window in which the tooth can migrate faster in humans is 2 - 3 months [27]. However, a deeper understanding of this subject is needed.

Furthermore, it is necessary to analyze the possible consequences that may arise as a result of corticotomy. Ferreira noticed that while following the traditional approach, the height of the alveolar ridge was reduced in some cases [28,29]. As a result, more research is needed in the field, to develop a surgical approach using improved procedures that eliminate the need to remove the flaps [30].

CONCLUSIONS

1. Although there are morphological and structural differences between periodontal and bone tissues of different species, dental movements on the experimental animal model are helpful

in evaluating the potential of orthodontic biomechanics (bone metabolic rate is faster in dogs compared to human bone).
2. The Ni- Ti coil spring springs are frequently used in sagittal dental motions (mesial or distal), the movement induced by them is almost corporeal. (shape memory and superelasticity)
3. Corticotomy accelerates tooth movement by around 0.5 mm per month, as revealed in our study, but it is only recommended for adult patients since it is a surgical procedure that involves cutting the vestibular bone plate and needs anesthesia.
4. Acceleration of orthodontic treatment by corticotomy has indications in large-scale displacements (intrusion, distalization) , but these method increases the costs of orthodontic treatment.
5. It is important to evaluate the advantages and disadvantages of each orthodontic intervention, because the alveolar bone and the supporting periodontium react differently to different orthodontic forces, and the cases in which corticotomy is used must be carefully selected.

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REFERENCES

1. Bos A, Hoogstraten J, Prahl-Andersen B. Expectations of treatment and satisfaction with dentofacial appearance in orthodontic patients. *Am J Orthod Dentofac Orthoped.* 2003;123(2):127-32.
2. Sachdeva RC, Aranha SL, Egan ME, Gross HT, Sachdeva NS, Currier GF et al. Treatment time: SureSmile vs conventional. *Orhodontics* (Chic). 2012;13:72-85.
3. Sayers MS, Newton JT. Patients' expectations of orthodontic treatment: part 2—findings from a questionnaire survey. *J Orthod.* 2007;34:25-35
4. Filho HL, Maia LH, Lau TC, de Souza MM, Maia LC. Early vs late orthodontic treatment of tooth crowding by first premolar extraction: a systematic review. *Angle Orthod.* 2015;85(3):510–7.
5. Reitan K. Clinical and histologic observations on tooth movement during and after orthodontic treatment. *Am J Orthod.* 1967;53:721-745.
6. Dab S, Chen K, Flores-Mir C. Short and long-term potential effects of accelerated osteogenic orthodontic treatment: a systematic review and meta-analysis. *Orthod Craniofac. Res.* 2019;22:61-8.
7. Krishnan V, Davidovitch Z. On a path to unfolding the biological mechanisms of orthodontic tooth movement. *J Dent Res.* 2009; 88:597-608.
8. Kale S, Kocadereli I, Atila P, Asan E. Comparison of the effects of 1,25 –dehydroxycholecalciferol and prostaglandin E2 on orthodontic tooth movement. *Am J Orthod.* 2004;125:607–14.
9. Tyrovola JB, Spyropoulos MN. Effects of drugs and systemic factors on orthodontic treatment. *Quintessence Int.* 2001;32:365–71.
10. Darendeliler M.A, Zea A, Shen G, Zoellner H. Effects of pulsed electromagnetic field vibration on tooth movement induced by magnetic and mechanical forces: a preliminary study. *Aust Dent J.* 2007;52:282-7
11. Showkatbakhsh R, Jamilian A, Showkatbakhsh M. The effect of pulsed electromagnetic fields on the acceleration of tooth movement. *World J. Orthod.* 2010;11:52-6.
12. Mostafa YA, Fayed MMS, Mehanni S, ElBokle NN, Heider AM. Comparison of corticotomy-facilitated vs standard tooth- movement techniques in dogs with miniscrews as anchor units. *Am J Orthod Dentofacial Orthop* 2009;136:570-7.
13. Cohen G, Campbell PM, Rossouw PE, Buschang PH. Effects of increased surgical trauma on rates of tooth movement and apical root resorption in foxhound dogs. *Orthod Craniofac Res* 2010;13:179-90.
14. Wilcko W, Wilcko MT. Accelerating tooth movement: the case for corticotomy-induced orthodontics. *Am J Orthod Dentofacial Orthop.* 2013;144(1):4–12.
15. Patterson BM, Dalci O, Darendeliler MA, Papadopoulou AK. Corticotomies and orthodontic tooth movement: a systematic review. *J Oral Maxillofac Surg.* 2016;74(3):453-73.
16. Al-Naoum F, Hajeer MY, Al-Jundi A. Does alveolar corticotomy accelerate orthodontic tooth movement when retract-ing upper canines? A split-mouth design randomized controlled trial. *J Oral Maxillofac Surg.* 2018;72:1880-9.
17. Bell WH, Levy BM. Revascularization and bone healing after maxillary corticotomies. *J. Oral Surg.* 1972;30:640-8.
18. Dab S, Chen K, Flores-Mir C. Short and long-term potential effects of accelerated osteogenic orthodontic treatment: a systematic review and meta-analysis. *Orthod. Craniofac Res.* 2019;22:61-8.
19. Zuppardo ML, Ferreira CL, Moura NB, Longo M, Santamaria M Jr, Lopes SL, et al. Macroscopic and radiographic aspects of orthodontic movement associated with corticotomy: animal study. *Oral Maxillofac Surg*. 2019;23(1):77-82.
20. Mostafa YA, Fayed MMS, Mehanni S, ElBokle NN, Heider AM. Comparison of corticotomy-facilitated vs standard tooth- movement techniques in dogs with miniscrews as anchor units. *Am J Orthod Dentofacial Orthop.* 2009;136:570-7.
21. Cho KW, Cho SW, Oh CO, Ryu YK, Ohshima H, Jung HS. The effect of cortical activation on orthodontic tooth movement. *Oral Dis.* 2007;13(3):314-9
22. Iino S, Sakoda S, Ito G, Nishimori T, Ikeda T, Miyawaki S. Acceleration of orthodontic tooth movement by alveolar corticotomy in the dog. *Am J Orthod Dentofacial Orthop*. 2007;131(4):448.e1-448.e4488.
23. Dutra EH, Ahmida A, Lima A, Schneider S, Nanda R, Yadav S. The effects of alveolar decortications on orthodontic tooth movement and bone remodelling in rats. *Eur J Orthod.* 2018;40(4):423-9.
24. Librizzi Z, Kalajzic Z, Camacho D, Yadav S, Nanda R, Uribe F. Comparison of the effects of three surgical techniques on the rate of orthodontic tooth movement in a rat model. *Angle Orthod.* 2017;87(5):717-24.
25. Filho HL, Maia LH, Lau TC, de Souza MM, Maia LC. Early vs late orthodontic treatment of tooth crowding by first premolar extraction: a systematic review. *Angle Orthod.* 2015;85(3):510–517.
26. Dab S, Chen K, Flores-Mir C. Short- and long-term potential effects of accelerated osteogenic orthodontic treatment: a systematic review and meta-analysis. *Orthod Craniofac Res.* 2019;22(2):61-8.
27. Peron AP, Johann AC, Papalexiou V, Tanaka OM, Guariza-Filho O, Ignácio SA, et. al. Tissue responses resulting from tooth movement surgically assisted by corticotomy and corticision in rats. *Angle Orthod.* 2017;87(1):118-24.
28. Spadari GS, Zaniboni E, Vedovello SA, Santamaria MP, Amaral ME, Santos GM, et al. Electrical stimulation enhances tissue reorganization during orthodontic tooth movement in rats. *Clin Oral Investig.* 2017;21(1):111-20.
29. Gil AP, Haas OL Jr, Méndez-Manjón I, Masiá-Gridilla J, Valls-Ontañón A, Hernández-Alfaro F, et al. Alveolar corticotomies for accelerated orthodontics: a systematic review. J Craniomaxillofac Surg. 2018;46(3):438-45.
30. Ferreira CL, Rocha VC, Ursi WJ, Marco AC, Santamaria M Jr, Santamaria MP et al. Periodontal response to orthodontic tooth movement in diabetes- induced rats with or without periodontal disease. J Periodontol. 2018;89(3):341-50.