Optimization approach for the mesialization of lower molars: a case report[1]

Técnica para la optimización del movimiento de ortodoncia en la mesialización de molares inferiores: reporte de un caso[1]

Virginia B. Montilla P.[2], *María Valentina Martínez M.*[3], *Dayanna Tomich B.*[4]

1 This clinical case was handled at the Dentofacial Orthopedics and Orthodontics Graduate Program of Universidad de Carabobo's School of Dentistry as a prerequisite to qualify for a degree of specialist.

2 DDS. Specialist in Dentofacial Orthopedics and Orthodontics. Adjunct Professor. School of Dentistry, Universidad de Carabobo. ORCID: 0000-0003-1203-0349

3 DDS. PhD in Dental Sciences, Specialist in Dentofacial Orthopedics and Orthodontics. School of Dentistry, Universidad de Carabobo. ORCID: 0000-0002-5375-2623

4 DDS. PhD in Dental Sciences. Oral and Maxillofacial Surgeon. Associate Professor. School of Dentistry, Universidad de Carabobo. ORCID: 0000-0002-6671-2487

Abstract

Premature molar loss results in inclination of teeth adjacent to the edentulous gap, uneven marginal ridges, posterior collapse of bite, and atrophy of the residual bone width. The orthodontic treatment aimed at closing post-extraction spaces is one possible treatment plan. However, in many cases this movement is compromised by the collapse of cortical plates and the decrease of the osseous corridor. Due to this problem, flexicorticotomy may be considered as an alternative in the mesialization of molars to improve residual bone width and to accelerate orthodontic movement. A 22-year-old female patient underwent extraction of the right mandibular first molar. A flexicorticotomy was performed to accelerate the mesial movement of teeth number 37 and 38, using a miniscrew for absolute anchorage. This technique helped mesialize teeth number 37 and 38, attaining a stable class I relationship, thus finding an orthodontic solution to a problem that was historically treated only prosthetically. In conclusion, this technique facilitates the mesial movement of molars, reaching treatment goals more effectively, and saving costs by avoiding further prosthetic treatment.

Keywords:
movement, acceleration, alveolar bone loss, mesial movement

Resumen

La pérdida prematura de molares trae como consecuencia inclinación mesial de los dientes adyacentes a la brecha edéntula, rebordes marginales desiguales, colapso posterior de la mordida y atresia en el ancho del hueso residual. El cierre de espacio con tratamiento ortodóncico es uno de los posibles tratamientos; sin embargo, en muchos casos ese movimiento se ve comprometido por el colapso de las tablas óseas y disminución del corredor óseo en el sitio postextracción. Debido a esta problemática, se ha propuesto el uso de la flexicorticotomía como coadyuvante en la mesialización de molares para mejorar el corredor óseo y acelerar el movimiento de ortodoncia. Se presenta una paciente de 22 años, quien acude a la consulta presentando ausencia de la UD 36. El plan de tratamiento a seguir consistió en flexicorticotomía para acelerar el desplazamiento de las UD 37 y 38 colocando un anclaje absoluto entre las UD 34 y 35. Dicho procedimiento se logró con una mecánica de mesialización con cadena elástica y anclaje absoluto. Se pudo mesializar las UD 37 y 38, manteniendo una relación clase I estable y encontrando una solución ortodóncica a un problema que anteriormente era tratado netamente de manera protésica. Se concluye que esta técnica mejora el movimiento de los molares hacia adelante y abre una nueva gama de posibilidades al permitir movimientos que anteriormente estaban limitados; además, permite cumplir objetivos de tratamientos de manera más efectiva, brindando una alternativa más eficiente y ahorrando costos al prescindir del tratamiento protésico.

Palabras clave:
movimiento, aceleración, pérdida de hueso alveolar

Submitted: January 21/2018 - Accepted: May 30/2019

How to quote this article: Montilla VB, Martinez MV, Tomich D. Optimization approach for the mesialization of lower molars: a case report. Rev Fac Odont Univ Antioq. 2020; 32(1): 89-103. DOI: http://dx.doi.org/10.17533/udea.rfo.v32n1a9

INTRODUCTION

The orthodontic movement aimed at closing posterior edentulous gaps is a clever idea but often difficult to perform due to a decrease in residual alveolar ridge width and the common collapse of the vestibular and lingual tables at the extraction site, especially if it has been done long ago.[1]

Premature loss of the first permanent molar is very common because it appears in the oral cavity at an early age, with more chances to experience cavities and to require early extraction.[2,3] This causes the mesial inclination of the second and third molars, distalization of premolars, extrusion of the antagonist molar, alteration of the gingival margin to the inclined molar, uneven marginal ridges, food impaction and finally bite collapse, producing occlusal interferences, periodontal diseases, bruxism, decreased chewing effectiveness and alterations at the temporomandibular joint.[4-6] Therefore, one of the possible treatments is the orthodontic closure of these edentulous spaces.

The loss or extraction of a tooth affects the alveolar bone by approximately 40% to 60%, in both height and thickness between the second and third years after extraction.[7] This causes collapse of vestibular and lingual tables, decreasing the normal width of the bone passage.[1]

Orthodontic movement depends on multiple factors, the most important being the jaws' bone composition. Movements in the maxillary bone can be achieved more quickly than in the mandible, because the maxillary bone has relatively thin corticals interconnected by a network of trabeculae and a spongy bone. The mandible, on the other hand, has more compact corticals in a more radial direction, connected by relatively thick trabeculae that hinder the movement of the molars.[8]

Patient's age is another important factor since orthodontics in adults implies several aspects that must be considered, such as the state of health of periodontium and alveolar bone, which is more compact due to greater bone condensation. There is also reduction of the spongy bone and decrease in bone volume, with decreased cellular response; this results in slowed and limited orthodontic treatment.[9-12]

All this makes orthodontic movement difficult, forcing the orthodontist to apply more mechanical force to move the affected tooth, resulting in problems such as necrotic sites or hyalinization of the periodontal ligament, loss of marginal bone, dehiscence, fenestration and root resorption due to excessive force.

In view of the consequences of losing a tooth unit, this study proposes a technique to achieve the closure of space, reducing orthodontic treatment time and avoiding unnecessary or overly complex dental movements, as well as the possible side effects during closure.

It is also important to bear in mind the physiology of the alveolar bone, which has a cortical layer formed by compact bone—difficult to remodel— and another layer of spongy or trabecular bone—which is the area where orthodontic movement mainly occurs—.[13,14] Thus, the rate of dental movement is the catabolic activity mediated by osteoclasts, which perform remodeling and bone destruction functions when required by the body.[9,13,15,16]

The theoretical linear rate of osteoclasts reabsorption during cortical bone remodeling is estimated at 0.6 mm/month

through the cortical bone. However, a clinical study in adults showed that the linear reabsorption rate at the interface of the lower molars periodontal ligament was significantly lower.[17-24]

This is why the present study particularly recommends the technique used by Mejía (1994), called flexicorticotomy, which by cutting the cortical bone layer separates its lingual/palatal portion from its vestibular portion, creating a corridor or sulcus that allows the movement of a tooth or group of teeth to large distances through the bone, thus minimizing treatment time in cases with atrophied bone corridors or narrow residual ridges.[1,11,12]

It is then understood that this new surgical gap created by strapping the residual ridge tables would behave like a simple exodontia that allows the formation of blood clot and then transform itself into spongy bone that facilitates teeth displacement.[1,11,25,26] In turn, this technique induces a response in the alveolar bone that can demineralize bone tissue around the dental roots, producing a transient osteopenia. Once this has happened, there is the so-called "window" of 3 to 4 months to quickly move the teeth through the demineralized bone matrix. This bone response is known as *regional acceleratory phenomenon* or RAP.[27]

Thus, the term *regional* in demineralization of both the cutting side and the adjacent bone, and the term *acceleratory* both refer to an exaggerated or intensified bone response of osteoclasts and osteoblasts, which increase in number by multicellular mediator mechanisms containing precursors, helper cells, blood capillaries, and lymphocytes, extending to the spongy bone, without greatly affecting the intramedullary vessels, which is beneficial for optimal bone regeneration thanks to accelerated bone remodeling.[3,16,21,28,29]

In the flexicorticotomy technique, no suture is done to avoid confronting the edges of the incision and to maintain gained width. Below is a description of the surgical procedure:[1,25,26]

1. Infiltratory anesthesia in the corresponding area
2. Incision on the edentulous edge
3. Intracrevicular incisions
4. Full-thickness flap lift
5. Consecutive perforations on the cortical from mesial to distal, in an apical direction to the spongy bone
6. Longitudinal fracture lines are done on the bone adjacent to the neighboring vestibular or lingual teeth in the mid-proximal area towards the toothless space
7. Bone girdles are separated from adjacent teeth following the axes of teeth
8. Bone tables are separated by slowly strapping them towards vestibular or lingual until the desired expansion of the bone passage
9. The surgical alveolus fills with blood and forms the clot needed for bone neoformation. Dental movement can be performed immediately if the apparatus is already in place or else wait 8 days to place the apparatus.

When the collapse length is longer than the mesio-distal distance of a tooth, it is recommended to fill the new surgical alveolus with collagen sponges, freeze-dried bone, or resorbable hydroxyapatite, to avoid collapsing the tables, keep them separated to avoid pressure from surrounding soft tissues, and avoid bony defects by the time treatment is completed.[1]

Also, with this surgical technique it is possible to move the teeth immediately after surgery.[1] This is why the mesialization of molars with the help of flexicorticotomy allows to make the most of cellular activity to accelerate orthodontic movement. Especially when this mesialization is performed with the help of an absolute anchorage with miniscrews which help maintain the anterior coupling and perform the dental movements without losing anchorage, which offers advantages to both patient and orthodontist.

CASE DESCRIPTION

This is the case of a 22-year-old female patient who consulted the Universidad de Carabobo's Dentofacial Orthopedics and Orthodontics Graduate Program for assessment and orthodontic treatment. Medical history was done upon obtaining her informed consent, showing that the patient does not have personal or family history of medical conditions. The extraoral clinical examination showed that the patient has an oval face with mild facial asymmetry and convex profile.

The oral clinical examination shows moderate upper crowding, 2.5 mm horizontal overbite and 2.5 mm vertical overbite. She also has Class I molar relationship in the right side and non-registerable relationship in the left side due to the absence of dental piece 36, and Class I canine relationship in both sides. Spee's Curve: 2mm right, 3.5 mm left, multiple tooth rotations and absence of tooth 36 causing depression of vestibular bone table (Figure 1).

Figure 1. Initial intraoral photographs
Source: by the authors

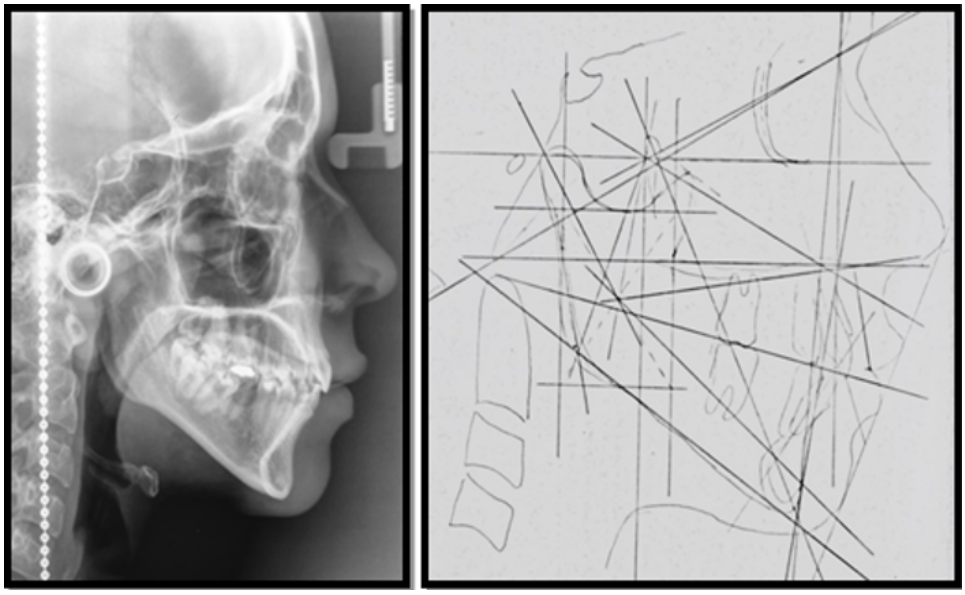

Figure 2. Initial lateral cephalic Rx with Ricketts cephalometric analysis

Source: by the authors

Radiographic evaluation

Conventional studies were conducted, including panoramic and lateral cephalic radiography (Figure 2).

Distance between teeth 35 and 37

The distance between the vestibular cusp of tooth 35 and the mesiobuccal cusp of tooth 37 pre-treatment was measured as 14 mm.

Diagnosis

- Skeletal: Class II. Facial biotype: mesofacial. Profile: convex
- Functional: protrusive interference
- Dental: Anderson: Class I, type 1. Proffit: 1. Proclination of the upper incisors
- Lower incisors protrusion

Treatment plan

Roth slot 0.022″ orthodontic apparatus was placed, performing the following actions: alignment and leveling, placement of orthodontic implant between teeth 35 and 34, flexicorticotomy for the mesialization of teeth 37 and 38, completion and containment, placing upper and lower circumferential retainer.

Treatment phases

Phase 1. Alignment and planing

The following sequence of archwires was used during a 5-month period (Figure 3):

1) 0.012″ NiTi archwhire. Super Elastic

2) 0.014″ NiTi archwhire. Super Elastic

3) 0.018″ NiTi archwhire. Super Elastic

4) 0.017″ x 0.025″ NiTi. Super Elastic

5) 0.018″ x 0.025″ NiTi. Super Elastic

Figure 3. Intraoral photographs. Alignment and leveling, 0.022″ Roth fixed orthodontic apparatus

Source: by the authors

Phase 2. Work

At this stage, anterior upper interproximal stripping was performed to correct the mild crowding and improve overjet. Flexicorticotomy was performed to achieve the displacement of teeth 37 and 38 in less time. Absolute anchorage was placed with ortho implant of 8 x 1.7 mm and .022″ slot between teeth 34 and 35, conducting mesialization with orthoimplant chain to the power-arm of teeth 37, achieving a mass movement. Stainless steel 0.018″ x 0.025″ archwire was used (Figure 4).

Lower impressions and photographs were also taken one, three, six, nine months and one year later to observe and quantify the mesialization of tooth units (Figure 5 and 6).

Figure 4. Flexicorticotomy

Source: by the authors

Figure 5. Intraoral photographs, flexicorticotomy, and placement of orthoimplant and power arm

Source: by the authors

Figure 6. Intraoral photographs. Follow-up 1 year after flexicorticotomy

Source: by the authors

Phase 3. Completion

Coordinated stainless steel archwires of 0.017″ x 0.025″ mm were placed. Upper Gingivoplasty. Replacement of brackets in teeth 24 and 25 (Figure 7).

Phase 4. Retention

A circumferential retainer was used in both upper and lower areas.

Final Case Results. (Figures 8, 9 and 10)

- Protrusive interferences
- *Left molar relationship*
- Upper anterior crowding
- Lower middle line
- *Right and left* curve of Spee
- Proclination of upper incisors
- Lower incisors protrusion
- *Rotation* of 13, 12, 22, 23, 25, and 35
- Mesialization of teeth 37 and 38

Figure 7. Completion
Source: by the authors

Figure 8. Final intraoral photographs
Source: by the authors

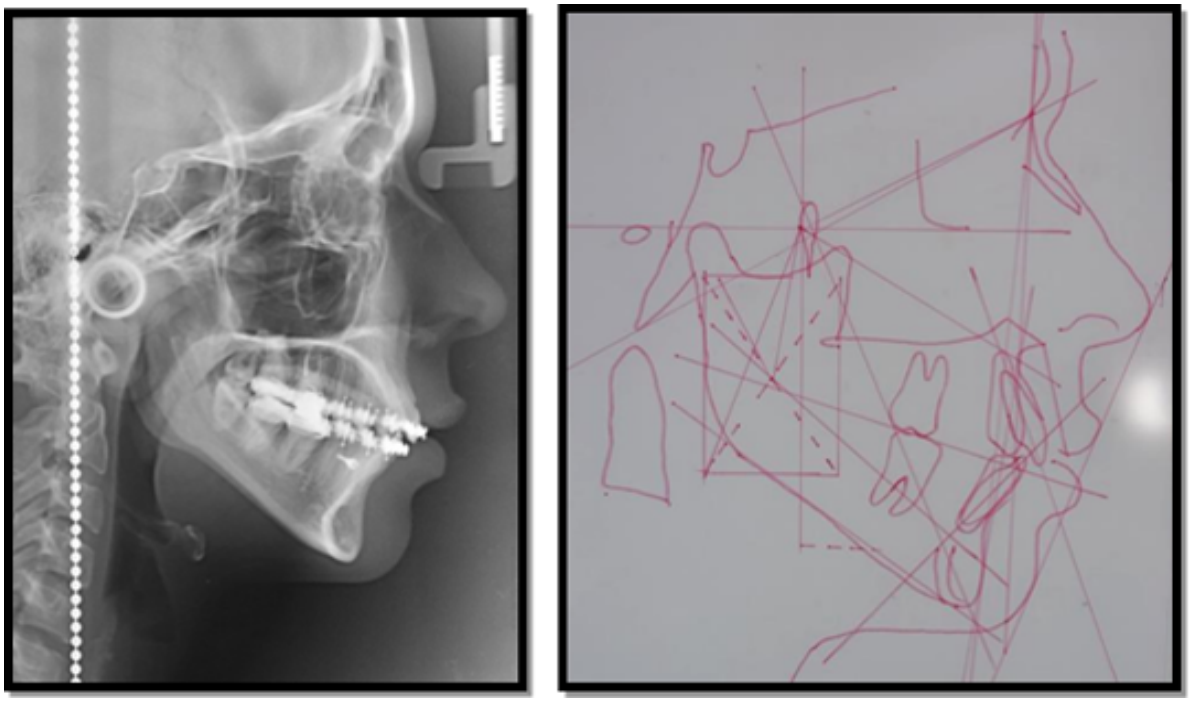

Figure 9. Final lateral cephalic Rx with Ricketts cephalometric analysis

Source: by the authors

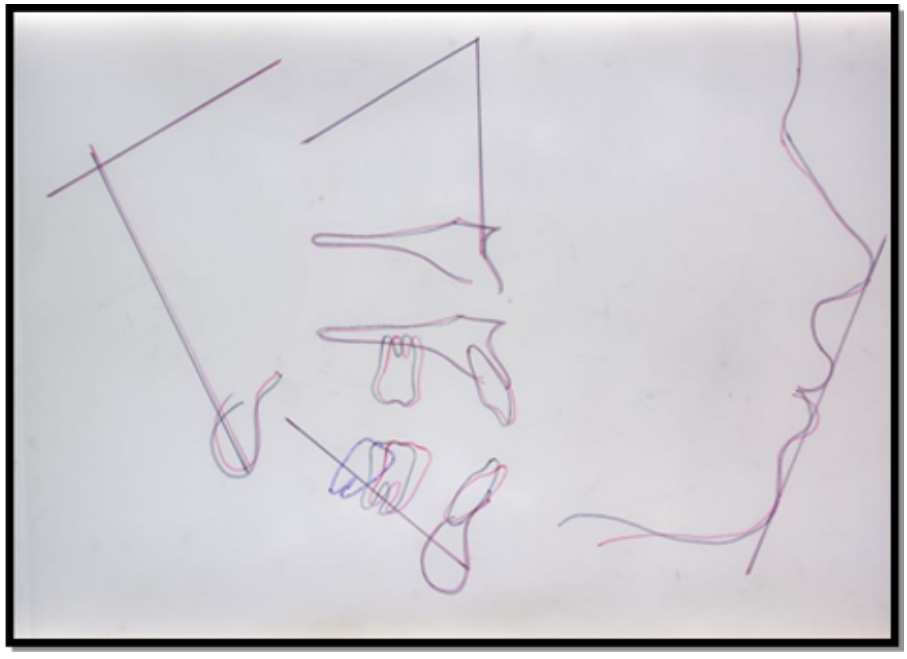

Figure 10. Cephalometric superimposition, showing mesialization of tooth 36. In purple: tooth 36 pre-treatment, in red: tooth 36 post-treatment.

Source: by the authors

RESULTS

The mesialization of second and third lower molars was monitored for a year, taking the distance between the vestibular cusp of tooth 35 and the mesio-vestibular cusp of tooth 37—which was 14 mm—as an initial measurement. In the first month after flexicorticotomy, there was a 1 mm closure; at 3 months it was 3 mm, at 6 months it was 5 mm, at 9 months it was 6 mm, and one year after the procedure the closure between dental pieces reached 8 mm.

DISCUSSION

Orthodontic movement is influenced by increased alveolar bone metabolism and decreased bone density. Therefore, the bone turnover rate determines the quantity and quality of movements. High bone turnover significantly increases the rate of dental movement.[13,22-24,27,28] For this reason, flexicorticotomy seeks to modify the cortical layer of alveolar bone with minimal alteration of the spongy or spinal bone, influencing the bone turnover rate, significantly increasing the number of osteoclasts, which are known to be responsible for the removal of bone on the pressure side of the applied force, and thus accelerate the orthodontic movement.[1,3,25,29-31]

The regional acceleratory phenomenon described by several authors (Hiaji, 2000, Frost, 1989 and Wilcko, 2009) has been proven over the years, offering insights into bone histology and physiology of the orthodontic movement. Lee (2006) found that this surgical technique works well due to induction of a transient osteopenia at the lesion site, which triggers exaggerated cellular activity, intensifying the transformation of macrophages into osteoclasts, and thus healing occurs 2 to 10 times faster than a physiological healing, offering a time window to accelerate orthodontic movement, which begins within a few days of the injury, with typical peaks at 1 to 2 months, and usually lasts up to 4 months, but may take up to 6 to 24 months to decrease.[8,10,11,32,33,34] However, according to Saad's study (2010), RAP remains while the orthodontic movement continues, and once it stops, the same will occur with osteopenia.[11,12,33,34]

Mejía (1994) and Martínez (2010) reported similar results in their cases, obtaining full mesialization of second and third molars for the edentulous space of the former in 18 months—an orthodontic movement that normally takes 24 to 36 months to complete.

Flexicorticotomy is thus a technique that opens new windows to orthodontics, expanding the range of movements to be performed especially in adult patients, reducing periods of time to half the conventional total lapse, achieving movements that were limited in the past, and reaching treatment goals more effectively by combining orthodontics with surgical treatment to solve all patients' needs.[26,32,34,35]

Finally, the periodontium is preserved during flexicorticotomy because no moderate or advanced resorptions are produced. This shows that a systematized orthodontic therapy after the surgical act provides rapid movement and support for relocated teeth. The presence of normal bone repair and X-ray evidence of bone formation are extensive evidence of the remarkable restorative properties and versatility of the involved connective tissue.[26,32,35,36,37]

CONCLUSIONS

The flexicorticotomy approach helped accelerate dental movement, with added benefits to patient as it reduces treatment time. This technique makes difficult movements possible, as it successfully mesializes lower molars, thus eliminating the use of prosthetics.

Similarly, the use of flexicorticotomy did not produce root resorptions, nor gingival dehiscences, achieving the full closure of edentulous space in a short period of time.

RECOMMENDATIONS

The findings of the present study suggest that flexicorticotomy is a particularly useful tool for orthodontists after an adequate diagnosis of the clinical case; however, it is recommended to use it only when it is really necessary. It is also essential to analyze the following aspects:

- Always evaluate the ridge section because the outcome would be unpredictable in the presence of a large disto-mesial amount of edentulous ridge.
- Evaluate ridge type because it is contraindicated in knife-edged ridges due to risk of bony table fracture.[3]
- Assess bone quality to reduce fracture risk.
- Dental movement can be performed immediately if the appliance is already in place, or else wait 8 days to install the apparatus and start closing.[36]
- It is recommended to activate orthodontic appliance every fortnight to make the most of the surgical procedure, especially in the weeks of greatest osteopenia, namely weeks 4th to 6th, which according to the literature is when the most movement occurs.[33]
- In all cases, the start of orthodontic force should not be delayed more than 2 weeks after surgery. A longer delay could cause failure or decrease the advantages offered by the shorter period when RAP occurs.[33]
- A permanent orthodontic-periodontal assessment, follow-up, and maintenance is recommended while dental movement is being performed.
- Collagen sponges, freeze-dried bone, resorbable hydroxyapatite, or autologous bone should be used to fill the surgical alveolus when the collapse length is longer than the mesio-distal distance of a tooth.
- Antibiotics and pain medications should be given. However, the administration of anti-inflammatory agents is not recommended because it can theoretically interfere with the regional acceleratory process. It is also recommended to apply ice packs to the affected areas to decrease the severity of any possible edema or postoperative inflammation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

CORRESPONDING AUTHOR

Virginia Beatriz Montilla Puente
Universidad de Carabobo
+5804124042139
virimontillap@gmail.com
Av. Diaz Moreno, entre Infante y Sucre. Casa 85-9
Valencia, Carabobo. Venezuela

REFERENCES

1. Mejía Burgos E. Flexicorticotomia: una solución al colapso del reborde alveolar. Revista Odontos. 200(7); 27-31.
2. Boj Quesada JR, Cortés Lilo O, Canalda Sahli C. Tratamiento de un molar permanente inmaduro necrótico mediante pulpotomía. Endodoncia. 1995; 13(3): 148-52.
3. Müller F, Naharro M, Carlsson GE. What are the prevalence and incidence of tooth loss in the adult and elderly population in Europe? Clin Oral Impl Res. 2007; 18(Suppl 3): 2–14 DOI: https://doi.org/10.1111/j.1600-0501.2007.01459.
4. Wheeler NN. Anatomía dental, fisiología y oclusión. 7ª ed. Con formato en español Colombia: McGraw Hill; 1995.
5. Alvarez JO, Navia JM. Nutritional, tooth eruption, and dental caries, a review. Am J Clin Nutr. 1989; 49(3): 417-26. DOI: https://doi.org/10.1093/ajcn/49.3.417
6. Pérez, G. Curas Formocresoladas en dientes permanentes. Acta Odontol Venez. 1995; 33(1): 17-22.
7. Midgerr RJ, Shaye R, Fruge JF. The effect of altered bone metabolism on orthodontic tooth movement. Am J Othod. 1981; 80(3): 256–62. DOI: https://doi.org/10.1016/0002-9416(81)90289-x
8. Bermudez S, González AV, Márquez JD, Restuccia G, Kammann MA, Zambrano O et al. Prevalencia de caries y tratamientos realizados en el primer molar permanente en la población de Rio Chio. Estado Miranda, Venezuela. Acta Odontol Venez. 2013; 51(4).
9. Melsen B. Limitations in adult orthodontics. In: Melsen B, editor. Current Controversies in Orthodontics. Chicago, IL: Quintessence; 1991. pp. 147–80.
10. Miyajima K, Nagahara K, Lizuka T. Orthodontic treatment for a patient after menopause. Angle Orthod. 1996; 66(3): 173- 80. DOI: https://doi.org/10.1043/0003-3219(1996)066%3C0173:OTFAPA%3E2.3.CO;2
11. Hernández Duque C, Herrera Herrera A, Diaz Caballero A, Antines Freitas D. Unión de técnicas ortodónticas con flexicorticotomía periodontal para el manejo de tratamiento ideal. Salud Uninorte. 2012; 28(3): 419-24
12. Sharpe W, Reed B, Subtelny JD, Polson A. Orthodontic relapse, apical root resorption, and crestal alveolar bone levels. Am J Orthod Dentofacial Orthop. 1987; 91(3): 252–8. DOI: https://doi.org/10.1016/0889-5406(87)90455-0
13. Graber LW, Vanarsdall RL. Fisiología metabolismo y biomecánica del hueso en la práctica ortodóncica. 2006.
14. Scott P, DiBiase AT, Sherriff M, Cobourne MT. Alignment efficiency of Damon 3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008; 134(4): 470.e1-8. DOI: https://doi.org/10.1016/j.ajodo.2008.04.018
15. Roberts E, Huja S, Roberts Jeffery. Bone modeling: biomechanics, molecular mechanisms, and clinical perspectives. Semin Orthod. 2004; 10(2) 123-61. DOI: https://doi.org/10.1053/j.sodo.2004.01.003
16. Chung KR, Oh MY, Ko SJ. Corticotomy-assisted orthodontics. J. Clin Orthod 2001; 35(5): 331-9.
17. Roberts WE. Bone physiology, metabolism, and biomechanics in orthodontic practice. In: Graber T, Vanarsdall R (eds). Orthodontics Current Principles and Techniques. St Louis, MO: Mosby, 2000. pp 193-257.

18. Roberts WE, Arbuckle GR, Analoui M. Rate of mesial translation of mandibular molars using implant-anchored mechanics. Angle Orthod. 1996; 66(5): 331–38. DOI: https://doi.org/10.1043/0003-3219(1996)066%3C0331:ROMTOM%3E2.3.CO;2

19. Sebaoun J, Kantarci A, Turner JW, Carvalho RS, Van Dyke TE, Ferguson DJ. Modeling of trabecular bone and lamina dura following selective alveolar decortication in rats. J Periodontol. 2008; 79(9): 1679–88. DOI: https://doi.org/10.1902/jop.2008.080024

20. Yeo A, Ong MM. Principles and implications of site preservation for alveolar ridge development. Singapure Dent J. 2004; 26(1): 15-20.

21. Frost HM. The biology of fracture healing. An overview for clinicians. Part I. Clin Orthop Related Res. 1989; (248): 283-93.

22. Goldie RS, King GJ. Root resorption and tooth movement in orthodontically treated, calcium-deficient, and lactating rats. Am J Orthod. 1984; 85(5): 424–30. DOI: https://doi.org/10.1016/0002-9416(84)90163-5

23. Engström C, Granström G, Thilander B. Effect of orthodontic force on periodontal tissue metabolism: a histologic and biochemical study in normal and hypocalcemic young rats. Am J Orthod Dentofacial Orthop. 1988; 9(6)3: 486–95. DOI: https://doi.org/10.1016/0889-5406(88)90077-7

24. Roberts WE, Goodwin WC Jr, Heiner SR. Cellular response to orthodontic force. Dent Clin North Am. 1981; 25(1): 3–17.

25. Martínez MA, Tomich D, Ucero CT, Spina MN. La Flexicorticotomía como procedimiento para la mesialización de un molar inferior en pacientes adultos: reporte de un caso. Acta Odontol Venez. 2013; 51(3).

26. Köle H. Surgical operation on the alveolar ridge to correct occlusal abnormalities. Oral Surg Oral Med Oral Pathol Oral. Radiol Endod. 1959; 12(5): 515-29. DOI: https://doi.org/10.1016/0030-4220(59)90153-7

27. Suya H. Corticotomy in orthodontics. In: Hosl E, Baldauf A, editors. Mechanical and biological basics in orthodontic therapy. Germany: Huthig Buch Verlag; 1991. p. 207-226

28. Verna C, Dalstra M, Melsen B. The rate and the type of orthodontic tooth movement is influenced by bone turnover in a rat model. Eur J Orthod 2000; 22(4): 343-52. DOI: https://doi.org/10.1093/ejo/22.4.343

29. J Hu, J Li, D Wang, MJ Buckley, Agarwal S. Differences in mandibular distraction osteogenesis after corticotomy and osteotomy. Int J Oral Maxillofac Surg. 2002; 31(2): 185-9. DOI: https://doi.org/10.1054/ijom.2001.0193

30. Hajji SS. The influence of accelerated osteogenic response on mandibular decrowding [thesis]. St Louis: St Louis University; 2000.

31. Discacciati M, Létora M. Primer molar permanente: riesgo y afecciones en los primeros años: cátedra de odontopeditría. Argentina: Universidad Nacional del Nordeste de Argentina; 2004.

32. Murray C, Ezzati DM, López AD, Rodgers A, Hoorn SV. Comparative quantification of heath risks conceptual framework and methodological issues. Popul Health Metr. 2003; 1(1): 1-73. DOI: https://doi.org/10.1186/1478-7954-1-1

33. Wilcko WM, Wilcko MT, Bouquot JE, Ferguson DJ. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. Int J Periodontics Restorative Dent. 2001; 21(1): 9-19.

34. Martínez MV, Tomich D, Ucero CT. Aceleración del movimiento ortodóntico mediante corticotomías alveolares. Acta Odontol Venez. 2012; 50(4).

35. Herrera A, Simancas Pallares M, Díaz Caballero A. Uso de la flexicorticotomia como técnica quirúrgica coadyuvante para el tratamiento de ortodoncia. Acta Odontol Venez. 2011; 49(4).

36. Díaz Caballero A, Herrera Barrios F, Herrera Herrera A Flexicorticotomía: una técnica quirúrgica para tratamiento de ortodoncia. Reporte de un caso. Av Odontoestomatol. 2010: 26(5).

37. Cervera A, Perara R, Cervera AJ. Movimiento mesial de molares inferiores con la tecnica de arco recto-C. 1era parte: biomecannica de laboratorio. Rev Esp Ortod. 2000; 30: 317-24.