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The effect of buccal shelf miniscrew retraction techniques on alveolar bone remodeling of mandibular anterior area

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ABSTRACT

Bone remodeling is considered the main process occurred during orthodontic tooth movement especially affecting the alveolus. This process may be a risk factor for the development of gingival recessions, which are 5.8-11.5% common in orthodontically treated patients. The purpose of our study was to assess the changes in the alveolar bone at the level of lower central incisors in adolescent and adult patients after orthodontic tooth movements using CBCT (Cone beam computed tomography) scans. This review's criteria were met by 20 pts out of a total of 47. Retraction of lower incisors was carried out utilizing buccal shelf miniscrews by two en masse retraction techniques to assure full control of tipping movements during orthodontic treatment, the distance from the cementoenamel junction to marginal bone crest was measured before starting space closure and after 6 months. In both types of retraction techniques, the difference in the bone loss was greater on the lingual side of the incisors, especially in Group 1 which utilized a continuous elastomeric chain extended along the main archwire it was comparable to the retraction of lower anteriors within the chain connected to a hook attached to the wire at the level of the centre of resistance of lower anterior teeth between lower lateral and canine although the G1 had a higher retractive effect on lingual bone as compared to G2 (P value= 0.036). The lingual bone movement after retraction showed no statistically significant difference between both groups.

Keywords: En masse retraction, CBCT, buccal shelf miniscrew

INTRODUCTION

Orthodontic treatment relies heavily on bone remodelling caused by tooth movement. The shape of alveolar directly affected by orthodontic treatments that have strong influence on bone remodelling. 1

It is widely agreed that orthodontic movement should be done with full control preserving teeth within bone boundaries .2-4 Dehiscence and fenestration occur when tooth movement surpasses the alveolar bone barrier. Proffit proposed the concept of an "envelope of discrepancy" to indicate the boundaries of tooth movement5. Excessive anterior tooth retraction in patients with bimaxillary protrusion raises the risk of periodontal disease. 6-8

Because standard two-dimensional radiographs have limitations, lateral cephalograms and panoramic radiographs cannot accurately measure alveolar bone loss. Cone-beam computed tomography (CBCT) visualises the morphology of the tooth root and alveolar bone

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in three dimensions, making it more widely used in diagnostics and orthodontic treatment planning.9 CBCT is currently utilised with great accuracy and precision to assess alveolar bone height and thickness.10

CBCT has previously been used to assess alveolar bone alterations in the anterior region during orthodontic treatment. However, the outcomes are inconclusive. The amount of alveolar bone increase on the labial side and the amount of alveolar bone loss on the lingual side remain unknown in extraction patients.

Materials and methods

Study design

A randomized control clinical trial with parallel groups was carried out to evaluate the effect of the three-dimensional evaluation of two different mandibular en masse retraction techniques using mandibular buccal shelf miniscrews.

The techniques used were divided into two groups, (Group 1) where retraction at the level of the main archwire where the power chain extended continuously starting from minscrew at one side engaging the lower anterior teeth from left canine to the other canine then attached to the miniscrew at the opposing side [36]fig. vs hook retraction with retraction force at the level of the centre of resistance of lower anterior segments (Group 2)

Sample size calculation

The sample size calculation was performed using G.power 3.1.9.2 (Universitat Kiel, Germany). It was calculated as N ≥7 in each group based on the following considerations: 0.05 α error and 95% power of the study to demonstrate a mean difference in root retraction as an indicator of bone movement (our primary outcome) of (-3.55 ± 0.80) with the longer ARH of 9 mm vs (-2.15 ± 0.38) with that of 3 mm according to previous studies {Formatting Citation}. Three cases were added to each group to compensate for any possible dropout. Therefore, 10 patients will be allocated to each group.

Methods.

The patients were fitted with straight wire braces 0.018 inches with Roth prescriptions All patients underwent extraction of upper first premolars and lower first premolars according to their treatment plan. Some patients required extraction of mandibular premolars to level the curve of Spee or to relieve crowding. Initial alignment and levelling were performed with the wire sequence 0.012,0.014, 0.016-inch nickel titanium wires followed by 0.018-inch stainless steel wires, followed by 0.016 x 0.022-inch nickel titanium wires and 0.016 x 0.022-inch stainless steel wires. The regular appointment interval was every 4-5 weeks. Emergency visits were scheduled in case of broken brackets or buccal tubes. The first phase of levelling and alignment ranged between 5 to 6 months. After initial levelling and alignment, 0.017x 0.025-inch stainless steel wires were fitted for at least 4 weeks to ensure the passivity of the archwire.

At this point the patients were prepared for placing the buccal shelf miniscrews size 12 mm length and 2 mm diameter, localising the

target area opposing to the midpoint between the lower 6 distal roots and lower 7 mesial roots.[12]

Cone beam computed tomography (Scanora 3D, medium FOV 75 X 100 with voxel size 0.2 mm) [39]were taken at two-time intervals for the whole sample: T1: Before the onset of en-masse retraction. T2: After the completion of en-masse retraction and complete space closure.

After that, a cut was taken to record both labial and lingual bone height at the midline level of the lower anterior segment, the measurement was taken from the cementoenamel junction to the highest point of alveolar bone and lingually at the level of the lower left central incisor for all cases.

Results

Table 1: En Mass retraction effect on lingual bone height for group 1 & Group2:

		Group1 (n=10)	Group2 (n=10)	P value (Unpaired t-test)
Pre	mean ± SD	3.41 ± 0.31	3.45 ± 0.29	0.767
	Range	3.2 – 4.1	3.2 – 4	
Post	mean ± SD	4.11 ± 0.47	3.94 ± 0.28	0.34
	Range	3.6 – 5.1	3.6 – 4.5	
Change		0.7 ± 0.27	0.49 ± 0.12	**0.036***
P value (Paired t-test)		**<0.001***	**<0.001***	---

Data are expressed as mean ± SD and range, *: Statistically significant as p value ≤0.05. shows that both groups had comparable measurements of lingual bone height at the start of the study. After performing both techniques of En masse retraction, lingual bone significantly moved from its original site under the effect of retraction (P values<0.001).

By comparing both techniques, Group 1 showed a higher retractive effect on the vertical bone height of the lingual bone as compared to Group 2 (P value= 0.036). The lingual bone resorption after retraction showed statistically significant difference between both groups.

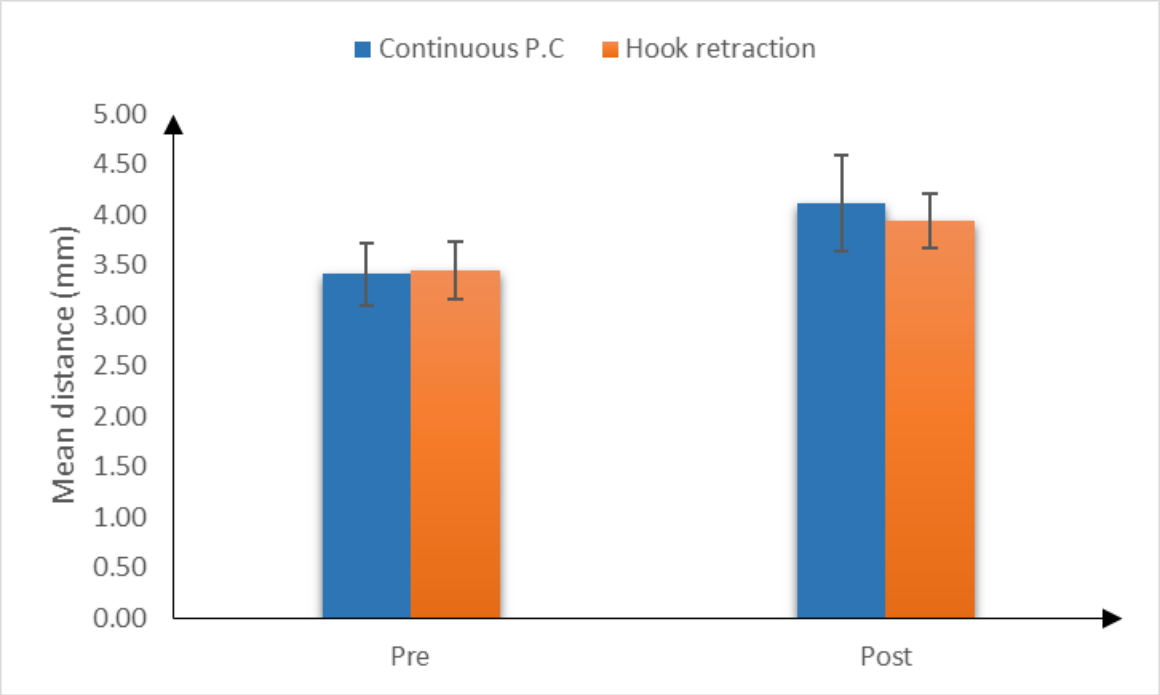

Figure 1: En Mass retraction effect on lingual bone After both En masse retraction techniques in group1 & group 2

Discussion

Space closure during orthodontic treatment is one of the main steps during the treatment. Space closure is done by retracting the teeth posteriorly either to close an extraction space or to close multiple diastemata between the teeth. It is crucial not only to move the teeth to close the spaces but also to maintain the teeth' vitality during this movement. One of the main factors to preserve teeth vitality is to keep the roots of the teeth enveloped by the alveolar bone from all directions and avoid any root dehiscence or fenestration.

During orthodontic retraction, alveolar bone defects such as fenestr ation

and dehiscence are prevalent. However, the relationship between tooth movement and changes in alveolar bone remains unknown.13,14 Dehiscence and fenestration during orthodontic treatment are caused by many things, including, but not limited to, the direction of tooth movement, the force of tooth movement, the magnitude of orthodontic forces, amount of tooth movement, size of alveolar bone, position of roots, and anatomical integrity of periodontal tissues15,16 In terms of anatomy, the alveolar bone in the mandible gets thinner from the back to the front. So, the direction and amount of tooth movement can easily go against the biological limits of the alveolar process in the area of the mandibular symphysis.[17].

Space closure in orthodontics can be done by more than one technique such as en masse retraction on the main-arch wire, 2-step retraction, or en-masse retraction using mini-screws[18]During the space closure phase,

both en masse and two-step retraction work well. The en masse/miniscrew combination is better than the two-step/traditional anchorage combination in terms of how well the anchorage stays in place and how much it can be pulled back.[19] so in our research, we combine en-masse retraction with buccal shelf miniscrew depending on the evidence that the L6db–L7mb area should be the first choice for placing miniscrews in the mandible to move the mandibular teeth distally[20].

Though not a novel therapeutic approach, the use of miniscrew implants to achieve absolute anchorage has recently gained popularity in clinical orthodontic approaches. Because of their temporary use, these implant systems facilitate a unique mode of anchorage, resulting in a transient, absolute, anchorage.[21] The morphology of the alveolar bone is a limiting factor for orthodontic movement and should be considered individually in orthodontic treatment planning.[22] So During retraction of the anterior teeth, supporting bone level changes, many studies tried to study these changes using different methods such as probing depth, periapical xrays, panoramas and recently cbct.

With the development of CBCT imaging, we now have a great way to diagnose and evaluate this. Timock et al. {Formatting Citation}compared CBCT with direct measurements on dead bodies to find the height of the buccal bone and thickness and found that most people agreed between CBCT and direct measurements of the height and thickness of the buccal bone, the mean absolute errors were small (0.30 and 0.13 mm, respectively), and there were no statistically significant differences or tendencies to under- or over-estimate. Interoperator and intraoperator reliability for CBCT measurements of the height (.0.97) and thickness of the buccal bone were very close (0.90) accordingly Sun et al. [24]found that both the sensitivity an d specificity rates of CBCT for dehiscence w ere over 0.7mm.

They concluded that the CBCT method might be too accurate. The 0.3mm voxel size w as chosen because it was a good balance betwe en the amount of radiation exposure and the cli nical importance of the study.

According to studies of John Hsu 1,[25] 20 patients of non-gender filtration was ideal for our study to allow for easily comparing data and avoid any drop out during the period of study, beside that the age range ensures healthy and normal physiological bone remodelling processes.

Absolute anchorage during en masse retraction got the privilege for our anchorage design during the study depending on the type of forces exerted during retraction and emphasized by Ye Zhu 1, [26] who revealed the effect of En-masse retraction on lingual bone and extrusive forces on the incisors and distal forces on the canines.

The best orthodontic treatment depends a lot on how well the clinician can predict and control how the teeth move by using a well-known force system on the teeth. It is very important to find out where the centre of resistance of a tooth or teeth is so that you can better understand how the teeth move under different levels of force.[27] according to A-

Ra Jo et al who reveal the best position for retraction is the 6 mandibular anterior teeth [28] we utilized a long hook between the lower central incisor and lower canine as The centre of resistance was 13.5 mm apical the incisal edge of the mandibular central incisors, and it was 8.5 mm distal the incisal edge of the mandibular central incisors in the anterior-posterior direction.

In our study, after space closure has finished vertical bone height was measured with the aid of a linear measurement tool on the CBCT software and then compared with initial measurements that have been taken and revealed that lingual bone significantly moved from its original site under the effect of En masse retraction which was in accordance with **Q. Sun *et al*.,2021** [29] who concluded that anterior alveolar bone width and height frequently reduced after orthodontic retraction while the alveolar bone height increased significantly on the labial side of the maxilla and **decreased significantly on the lingual side of the maxilla and mandible**, ***Edyta Kalina et al 2022*** [30] also reported that bone loss was larger on the lingual side of the incisors. The outcomes for adult patients were comparable. The thickness of the alveolar bone was reduced following proclination (total bone thickness) in both growing and non-growing patients, as well as a retraction (lingual and buccal) of the lower anterior teeth in the growing group, Mandibular incisor proclination or retroclination increased the distance between the CEJ and the marginal bone crest 31-34 according to ***Guo et al*** who concluded that alveolar bone height and thickness, especially at the cervical level, decreased during both labial and lingual movement of anterior teeth [35] these results can be explained according to the biomechanical diagram of using miniscrews for extraction as explained by ***R. Nanda et al 2005 (36)*** Due to the relative position of the retraction force to the estimated anterior segment Center of resistance, there is an anti clockwise moment on the lower anterior segment. This moment is impacted by the rigidity of the main arch wire as well as the amount of its use within the bracket's slot

Refrences

1. Ma J, Huang J, Jiang JH. Morphological analysis of the alveolar bone of the anterior teeth in severe high-angle skeletal Class II and Class III malocclusions assessed with cone-beam computed tomography. PLoS One. 2019;14(3):e0210461.

2. Lund H, Gröndahl K, Gröndahl H-G. Cone beam computed tomography evaluations of marginal alveolar bone before and after orthodontic treatment combined with premolar extractions. Eur J Oral Sci. 2012;120:201-211.

3. Shimizu Y, Ono T. Three-dimensional structural analysis of the morphological condition of the alveolar bone before and after orthodontic treatment. Korean J Orthod. 2017;47:394-400.

4. Kim Y, Park JU, Kook Y-A. Alveolar bone loss around incisors in surgical skeletal Class III patients. Angle Orthod. 2009;79:676-682.

5. Proffit WR, White Jr RP. Who needs surgical-orthodontic treatment? Int J Adult Orthodon Orthognath Surg. 1990;5:81-89.

6. Ahn H-W, Moon SC, Baek S-H. Morphometric evaluation of changes in the alveolar bone and roots of the maxillary anterior teeth before and after en masse retraction using cone-beam computed tomography. Angle Orthod. 2013;83:212-221.

7. Nayak Krishna US, Shetty A, Girija MP, Nayak R. Changes in alveolar bone thickness due to retraction of anterior teeth during orthodontic treatment: a cephalometric and computed tomography comparative study. Indian J Dent Res. 2013;24:736-741.

8. Nahm KY, Kang JH, Moon SC. Alveolar bone loss around incisors in Class I bidentoalveolar protrusion patients: a retrospective three-dimensional cone beam CT study. Dentomaxillofac Radiol. 2012;41:481-488

9. Mandelaris GA, Neiva R, Chambrone L. Cone-beam computed tomography and interdisciplinary dentofacial therapy: an American Academy of Periodontology best evidence review focusing on risk assessment of the dentoalveolar bone changes influenced by tooth movement. J Periodontol. 2017;88:960-977.

10. Timock AM, Cook V, McDonald T. Accuracy and reliability of buccal bone height and thickness measurements from cone-beam computed tomography imaging. Am J Orthod Dentofacial Orthop. 2011;140(5):734-744.

11 T. N. Yousry, S. Abdel-Haffiez, and M. M. J., vol. 59, no. 6, pp. 26–38, Jun. 2021, doi: 10.21608/EOS.2021.78005.1017.owafy, "The effect of varied force vector on type of tooth movement of maxillary anterior teeth during en masse retraction; randomized clinical trial," Egypt. Orthod

[12] C. Chang, S. S. Y. Liu, and W. E. Roberts, "Primary failure rate for 1680 extra-alveolar mandibular buccal shelf mini-screws placed in movable mucosa or attached gingiva," Angle Orthod., vol. 85, no. 6, pp. 905–910, Nov. 2015, doi: 10.2319/092714.695.1.

[13] Y. Sheng, H. M. Guo, Y. X. Bai, and S. Li, "Dehiscence and fenestration in anterior teeth: Comparison before and after orthodontic treatment," J. Orofac. Orthop., vol. 81, no. 1, pp. 1–9, Jan. 2020, doi: 10.1007/S00056-019-00196-4/TABLES/5.

[14] F. Wen, G. Chen, Y. L.-B. da xue xue bao. Y. xue ban, and undefined 2016, "Morphological analysis of roots and alveolar bone changes after upper anterior retraction with maximum anchorage based on cone-beam computed tomography," europepmc.org, Accessed: Dec. 31, 2022. [Online]. Available: https://europepmc.org/article/med/27538156.

[15] J. W.-S. in orthodontics and undefined 1996, "Mucogingival considerations in orthodontic treatment," Elsevier, Accessed: Dec. 31, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1073874696800399.

[16] H. Wehrbein, W. Bauer, … P. D.-J. of O. and D., and undefined 1996, "Mandibular incisors, alveolar bone, and symphysis afterorthodontic treatment. A retrospective study," Elsevier, Accessed: Dec. 31, 2022. [Online]. Available:

https://www.sciencedirect.com/science/article/pii/S0889540696800060.

[17] D. Swasty et al., "Anthropometric analysis of the human mandibular cortical bone as assessed by cone-beam computed tomography.," J. oral Maxillofac. Surg. Off. J. Am. Assoc. Oral Maxillofac. Surg., vol. 67, no. 3, pp. 491–500, Mar. 2009, doi: 10.1016/j.joms.2008.06.089.

[18] G. L. U. Ribeiro and H. B. Jacob, "Understanding the basis of space closure in orthodontics for a more efficient orthodontic treatment," Dental Press J. Orthod., vol. 21, no. 2, pp. 115–125, Mar. 2016, doi: 10.1590/2177-6709.21.2.115-125.sar.

[19] M. Z. Rizk, H. Mohammed, O. Ismael, and D. R. Bearn, "Effectiveness of en masse versus two-step retraction: a systematic review and meta-analysis," Prog. Orthod., vol. 18, no. 1, Dec. 2018, doi: 10.1186/S40510-017-0196-7.

[20] H. Liu, X. Wu, J. Tan, and X. Li, "Safe regions of miniscrew implantation for distalization of mandibular dentition with CBCT," Prog. Orthod., vol. 20, no. 1, pp. 1–8, Dec. 2019, doi: 10.1186/S40510-019-0297-6/TABLES/3.

[21] M. A. Papadopoulos and F. Tarawneh, "The use of miniscrew implants for temporary skeletal anchorage in orthodontics: a comprehensive review," Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., vol. 103, no. 5, May 2007, doi: 10.1016/J.TRIPLEO.2006.11.022.

[22] D. G. Garib, M. S. Yatabe, T. O. Ozawa, and O. G. da Silva Filho, "Alveolar bone morphology under the perspective of the computed tomography: defining the biological limits of tooth movement," Dental Press J. Orthod., vol. 15, no. 5, pp. 192–205, Sep. 2010, doi: 10.1590/S2176-94512010000500023.

[23] A. M. Timock et al., "Accuracy and reliability of buccal bone height and thickness measurements from cone-beam computed tomography imaging," Am. J. Orthod. Dentofacial Orthop., vol. 140, no. 5, pp. 734–744, Nov. 2011, doi: 10.1016/J.AJODO.2011.06.021.

[24] L. Sun, L. Zhang, G. Shen, B. Wang, and B. Fang, "Accuracy of cone-beam computed tomography in detecting alveolar bone dehiscences and fenestrations," Am. J. Orthod. Dentofacial Orthop., vol. 147, no. 3, pp. 313–323, Mar. 2015, doi: 10.1016/J.AJODO.2014.10.032.

[25] J. Hsu et al., "Patient choice. A randomized controlled trial of provider selection," J. Gen. Intern. Med., vol. 18, no. 5, pp. 319–325, May 2003, doi: 10.1046/J.1525-1497.2003.20145.X.

[26] Y. Zhu, W. Hu, and S. Li, "Force changes associated with differential activation of en-masse retraction and/or intrusion with clear aligners," Korean J. Orthod., vol. 51, no. 1, pp. 32–42, 2021, doi: 10.4041/KJOD.2021.51.1.32.

[27] H. K. Lee and K. R. Chung, "The vertical location of the center of resistance for maxillary six anterior teeth during retraction using three dimensional finite element analysis," Korean J. Orthod., vol. 31, no. 4, pp.

425–438, Jun. 2016, Accessed: Jan. 13, 2023. [Online]. Available: http://www.koreamed.org/SearchBasic.php?RID=2271992.

[28] A. R. Jo, S. S. Mo, K. J. Lee, S. J. Sung, and Y. S. Chun, "Finite-element analysis of the center of resistance of the mandibular dentition," Korean J. Orthod., vol. 47, no. 1, p. 21, 2017, doi: 10.4041/KJOD.2017.47.1.21.

[29] Q. Sun, W. Lu, Y. Zhang, L. Peng, S. Chen, and B. Han, "Morphological changes of the anterior alveolar bone due to retraction of anterior teeth: a retrospective study," Head Face Med., vol. 17, no. 1, pp. 1–12, Dec. 2021, doi: 10.1186/S13005-021-00277-Z/FIGURES/5.

[30] E. Kalina, A. Grzebyta, and M. Zadurska, "Bone Remodeling during Orthodontic Movement of Lower Incisors—Narrative Review," Int. J. Environ. Res. Public Heal. 2022, Vol. 19, Page 15002, vol. 19, no. 22, p. 15002, Nov. 2022, doi: 10.3390/IJERPH192215002.

[31] K. Matsumoto, S. Sherrill-Mix, N. Boucher, and N. Tanna, "A cone-beam computed tomographic evaluation of alveolar bone dimensional changes and the periodontal limits of mandibular incisor advancement in skeletal Class II patients," Angle Orthod., vol. 90, no. 3, pp. 330–338, May 2020, doi: 10.2319/080219-510.1.

[32] L. O. Castro, I. O. Castro, A. H. G. De Alencar, J. Valladares-Neto, and C. Estrela, "Cone beam computed tomography evaluation of distance from cementoenamel junction to alveolar crest before and after nonextraction orthodontic treatment," Angle Orthod., vol. 86, no. 4, pp. 543–549, Jul. 2016, doi: 10.2319/040815-235.1.

[33] C. Maspero, F. Gaffuri, I. O. Castro, V. Lanteri, A. Ugolini, and M. Farronato, "Correlation between Dental Vestibular–Palatal Inclination and Alveolar Bone Remodeling after Orthodontic Treatment: A CBCT Analysis," Mater. 2019, Vol. 12, Page 4225, vol. 12, no. 24, p. 4225, Dec. 2019, doi: 10.3390/MA12244225.

[34] H. Lund, K. Gröndahl, and H. G. Gröndahl, "Cone beam computed tomography evaluations of marginal alveolar bone before and after orthodontic treatment combined with premolar extractions," Eur. J. Oral Sci., vol. 120, no. 3, pp. 201–211, Jun. 2012, doi: 10.1111/J.1600-0722.2012.00964.X.

[35] R. Guo, L. Zhang, M. Hu, Y. Huang, and W. Li, "Alveolar bone changes in maxillary and mandibular anterior teeth during orthodontic treatment: A systematic review and meta-analysis," Orthod. Craniofac. Res., vol. 24, no. 2, pp. 165–179, May 2021, doi: 10.1111/OCR.12421.

36 R. Nanda, A. Kuhlberg, and F. Uribe, "Biomechanic basis of extraction space closure," Biomech. Esthet. Strateg. Clin. Orthod., pp. 194–210, 2005, doi: 10.1016/B978-0-7216-0196-0.50015-1.