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CLINICAL MODIFICATION IN ROOT CORRECTION PHASE IN SEGMENTED ARCH TECHNIQUE

The segmented arch technique uses the differential moment/force ratio in the anterior and posterior segments so that the extraction space in cases of critical anchorage can be closed with minimal or no anchorage loss. The objective of this article is to discuss the root correction phase, the force system involved, and the clinical problem of the tendency of space reopening during this phase. It also presents the use of a closed NiTi spring as a clinical alternative for this phase, concluding that this device can be used to avoid space reopening.
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The segmented arch technique (SAT) was developed by researcher and professor Charles Burstone[1] in the 1950s. It marked philosophical progress in terms of biomechanical improvement in the determination of the force system *(1)* to deliver relatively constant optimal forces and the use of the differential moment/force (M/F) ratio in the anterior and posterior segments, *(2)* to control active and reactive units in critical anchorage situations, and *(3)* to minimize the need for patient cooperation.[2,3] This technique allows the orthodontist to work in a predictable, scientific, and objective way, executing planned dental movements. Individualized mechanical planning, avoiding unnecessary or repetitive dental movements, results in more effective and stable orthodontic treatment.

Treatment with the SAT is divided into 4 main phases[2,4]: *(1)* alignment, leveling, and intra-arch segmentation to obtain the best tooth position in each segment; *(2)* intersegment alignment and leveling, which corrects the 3-dimensional relationships of the segments; *(3)* space closure, keeping in mind that the preactivation and the positioning of the loops in the interbracket distance will vary according to the anchorage (root correction may be required to provide a proper position to the roots); and *(4)* finalization, beginning with the re-leveling in a continuous arch and involving all necessary procedures to ensure esthetic and functional occlusion.

The space closure of the extraction site[5] in cases of maximum (type A) and minimum (type C) anchorage is accomplished in 2 steps: *(1)* space closure by controlled tipping of the segment where movement is desired (type A for anterior and type C for posterior); and *(2)* root correction, which is always necessary in cases of type A and C anchorage.

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Fig 1 Before **(a)** and after **(b)** space closure in type C mechanics. **(c)** Radiograph showing posterior segment when tipped.

For space closure in type A mechanics[5,6] (maximum anchorage), where the "T" loop is positioned[7] and precalibrated, the posterior M/F is about 12:1 (root movement), whereas the anterior M/F is about 7:1 (controlled tipping, Fig 1a). In type C mechanics (minimum anchorage), the opposite is seen: anterior M/F is 12:1, while posterior M/F is 7:1 (Figs 1b and 1c). The center of rotation should be in the apical region and at the incisal edge, respectively, for controlled tipping and root movement.[8]

When space closure in types A and C mechanics is completed, the active unit is tipped, requiring a second step: root position correction. This phase ensures proper root position in the segment moved by controlled tipping, considering that the dental crowns were moved into the extraction space, leaving the roots tipped.

For this task, the root correction spring[2,9] can be used, once it produces vertical forces and different moments in the anterior and posterior segments, depending on its preactivation. It can be prefabricated from a stainless steel 0.018 × 0.025-inch wire[2,10] and then fitted (Fig 2a) between the anterior and posterior segments to move the roots of one segment or one specific dental element. The highest moment (Fig 2b) should be produced in the unit that was tipped and needs root position correction, and the smaller moment in the reactive unit (Fig 2c).

The force system for root movement is planned according to the anterior segment and posterior segment geometry obtained at the end of the space closure.[2,9] Vertical forces may or may not be necessary, depending on the case. In the root correction stage, the center of rotation is displaced from the apical area to the incisal edge in the active unit.

The tendency for reopening of the previously closed space, while the root is uprighted, may be observed clinically. To avoid such a side effect, Burstone[2] tied back the active and reactive units by twisting a piece of 0.007 ligature wire to form a rope (Figs 2a to 2e). Marcotte[10] recommended that the segments be tied immediately after the space closure, using a 0.010/0.30 ligature wire. Despite this, the tendency for reopening remains in many clinical cases (Figs 2d and 2e). This problem is the clinical expression of a biomechanical failure in this stage of the technique, presenting a modification for this phase of the SAT. When comparing Figs 2b and 2c to 2d, the reopening of space is observed. Figure 3 shows the same problem in other clinical cases.

PROPOSED MODIFICATION

The first step in the biomechanical planning for the root correction is the analysis of the geometry presented by the anterior and posterior segments at the end of space closure. This will determine the optimal force system, as well as the ideal type of appliance for root correction, among several possibilities.[2,9,11]

The geometry of the segments may vary from 1 to 6, determining the necessary force system.[12] For example, a geometry 4[13] between anterior and posterior segments, in which a/l = 0.33, the

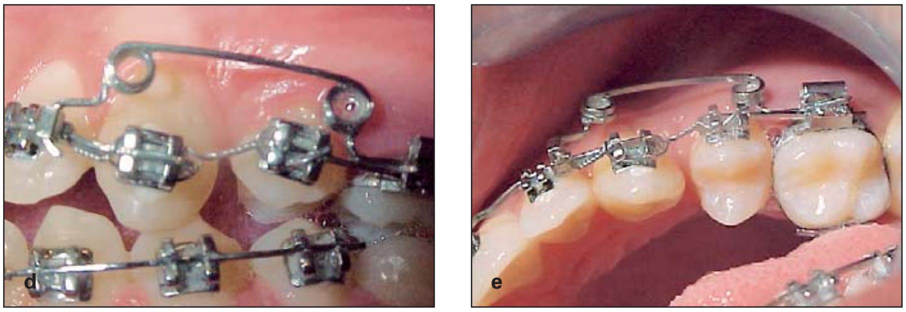



Fig 2 **(a)** Root correction spring in position. **(b)** Preactivation of 45 degrees in posterior segment (active unit). **(c)** Preactivation of 15 degrees in anterior segment (reactive unit). **(d)** Reopening of the extraction space 1 month after starting root correction phase. **(e)** Space reopening, occlusal view**)**.

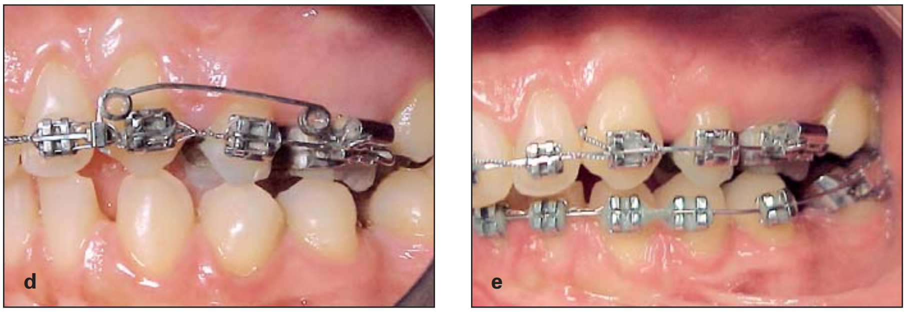
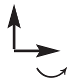
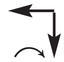
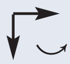



Fig 3 Various clinical cases in which the reopening of the space occurred during the root correction phase.

position of the "V" bend is exactly ⅓ of the distance from one of the brackets and the biomechanical principle for root correction is an asymmetrical "V" bend; the spring should then be preactivated 45 degrees in the anterior segment and 15 degrees in the posterior segment to establish the necessary system of force (Table 1).

The space reopening happens because the active unit (Fig 4a, anterior) is intruded, tipped, and away from the occlusal plane. Therefore, the length of the ligature wire used to tie these segments must also be larger. This distance decreases during the root correction stage, as the roots become properly positioned and the tipped segment approximates the occlusal plane (Fig 4b).

Table 1 Analysis of the geometry of the anterior and posterior segments

Anchorage type	Force system		Moment/force ratio	
	Anterior	Posterior	Anterior	Posterior
A			12:1 to 13:1	7:1
C			7:1	12:1

The geometry obtained at the end of the space closure, in this example, is type A, with a/l = 0.33 (asymmetric V). For root correction, it is necessary to have a couple and a vertical extrusive force in the anterior segment. The spring produces a consistent force system, since the forces and the moments are optimal for root correction.

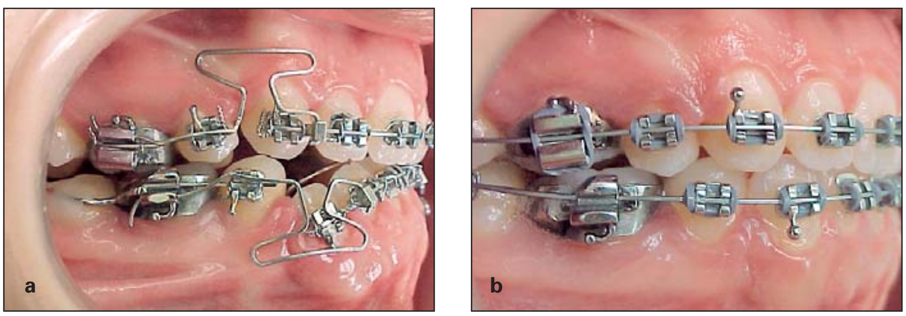


Fig 4 **(a)** Active unit (anterior segment) intruded, tipped, and at a distance from the occlusal plane. **(b)** Anterior segment after root correction, near the occlusal plane.

Moreover, the distance between the attachments in the anterior and posterior segments is greater at the beginning than at the end of this phase and therefore the ligature wire becomes larger than necessary at the end of root correction. The rigidity of the ligature wire and its inability to contract during the root correction becomes a problem, causing space reopening and movement of the anterior and posterior segments away from one another, while the distance between the segments decreases.

Considering that the SAT is based on the development of an ideal force system, avoiding repetitive and unnecessary dental movements,[1,2] the reopening of this space is undesirable and compromises the principles and efficiency of the technique.

The components' horizontal force (HF) and couple, produced from the preactived springs, also contribute to the reopening of the extraction site once they act in the force system in a dependent way. According to the spring design, the HF can be generated independently of horizontal activation, which can open or close the space obtained via extraction. Braun and Garcia[14] have shown that without horizontal activation, when the vertical legs of the loop are approached or moved away from one another in the neutral position, the generated HF will tend to open or to close the extraction space. This way, the bends used to create couples can influence the HF of the force system. In the case of the root spring, this is significant. The spring is not activated to create HF, but the preactivation bends will generate HF that tends to reopen the extraction site.

The 2 described processes are: *(1)* the rigidity and length of the ligature wire used to tie anterior and posterior segments, and *(2)* the liberation of HF by preactivation of the root spring. These 2 processes act together in a negative way, allowing the reopening of the extraction space during the root correction phase.

To solve this clinical problem, the authors suggest the use of a force system that contains a HF with intensity and direction that opposes the HF generated by the couple, produced from the preactivated root spring.

The force system suggested by the authors is composed of a couple, necessary to upright the active unit; vertical forces, whose intensities depend on the

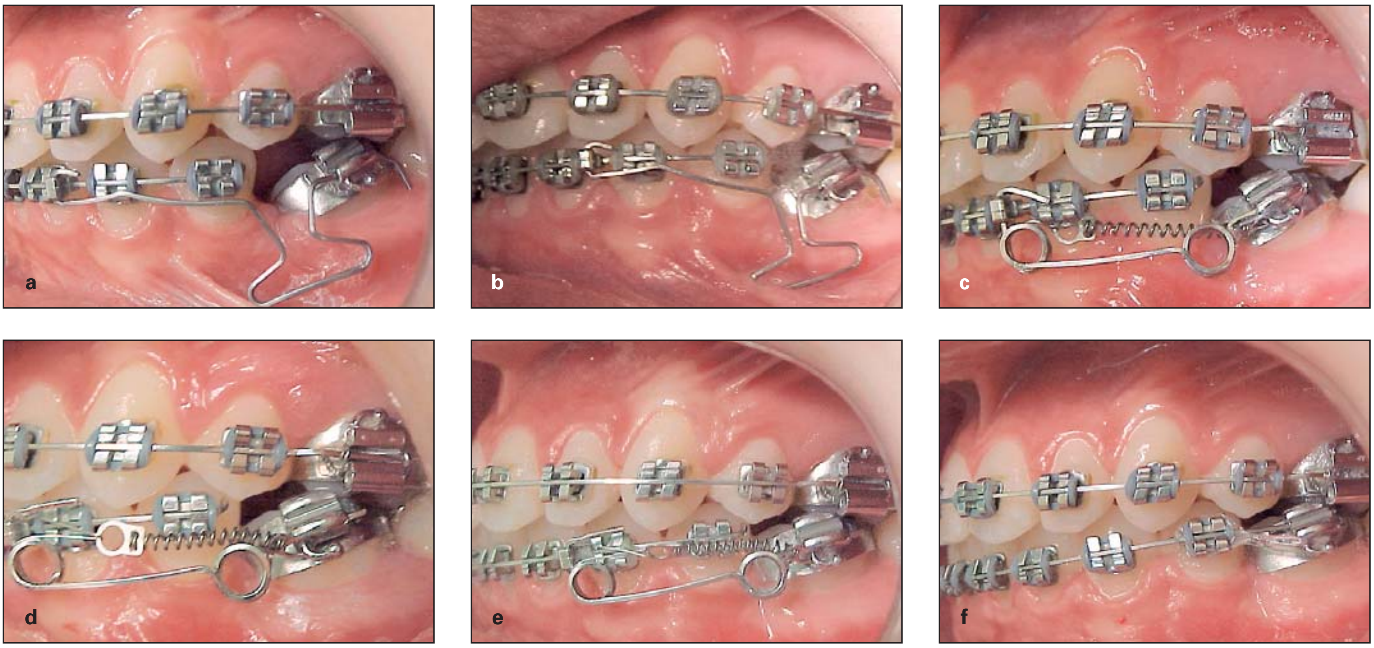


Fig 5 **(a)** During the space closure. **(b)** End of the space closure. **(c)** Beginning of root correction, using 0.018 × 0.025-inch stainless steel root spring, plus NiTi closed spring. White arrow, HF; yellow arrow, VF; green, couple. **(d,e)** Progress of root correction. **(f)** End of root correction.

geometry of the anterior and posterior segments at the end of the space closure; and horizontal forces in the direction of the space closure at the extraction site, produced by a NiTi closed spring placed between the anterior and posterior segments (Figs 5a to 5f). The horizontal forces are created by the NiTi closed spring that allows the approximation of the anterior and posterior segments while the roots are uprighted and the teeth approximate to the occlusal plane.

The authors have noticed that even after installing the NiTi closed spring, there was a tendency in some cases for a small reopening at the extraction site. This indicated that the HF produced by the spring was insufficient to neutralize the opposing horizontal force generated by the couples. The authors are conducting laboratory research, with high precision, to measure the intensity of these forces, so that activation can follow more objective orientations. Currently, the authors use about 300 g of force, delivered by a NiTi closed spring,[15] and the monthly appointment provides an opportunity to see whether or not the intensity of the horizontal activation needs to be changed.

CONCLUSION

The addition of a NiTi closed spring during the root correction phase has improved the final result, once it produces horizontal forces, by preventing space reopening during root correction, and, therefore, also reducing the time of final detailing in extraction cases.

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