Asymmetric Loop forms in anterior retraction arch wire

Allahyar Geramy [a], Reza Jelodar [b], Hasan Salehi [c]

Abstract

Aim: The aim of this study was to assess the effects of different loop forms in continuous arch technique on its force characteristics in the anterior retraction arch wires.

Material and Method: Six 3D finite element models were designed of an anterior retraction arch wire formed and included four average sized anterior brackets and the palatal wall of the bracket slot of the canines. The models were similar except for the height and angle of the loop legs. The left side loop was kept constant in all stages of the study while modifying the right side loop height or vertical leg's angulations. SolidWorks 2006 was selected for the modeling phase and ANSYS Workbench Ver. 11.0 for the calculations. Mesializing force on molar, medially directed force on canine, and anterior retraction forces were evaluated.

Results: According to the results, loop height in one side cannot affect the other side loop force characteristic directly; A gradual increase of the force difference between two side of the anterior retraction arch wire is shown. The mesializing force on molar is also increased with almost the same manner. The other findings related to loop leg divergence shows a difference between two sides but the differences are almost the same with varying degrees of divergence. Although the forces are not the same in both sides but the difference remained almost constant.

Conclusion: Arch wires may seem to be symmetric but may act asymmetric. Difference in anterior teeth retraction may be due to some asymmetries in arch wire fabrication which needs further considerations

Key words: Vertical loop, Anterior retraction, Asymmetric loop, Loop design

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Anterior retraction is an important step in many orthodontic treatments. Tooth movement with minimal tipping is often required for space closure. Depending on technique employed, different procedures are used for anterior retraction. The sliding mechanics has two disadvantages: Decreasing tooth movement; and unpredictable force of friction makes it impossible to know the amount of force delivered to the moving tooth.1The other procedure is retraction with a frictionless system by a closing loop into a continuous or segmented arch.[1-3]

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Several factors affect the loop efficiency. Reducing the wire cross section, Increasing the height of the spring, incorporating helix or helices in spring facilitates the delivery of optimum force.[1,4,5,6] Burstone and Koenig [1] showed that the M/F ratio increased with loop height and gingival side width and decreased with occlusal side width.

The other factor that affects the M/F ratio is the placement of the loop in an anterio-posterior direction.[1,7,8] Gable bend can also increase the M/F ratio.[1,5,9,10,11].An open vertical loop , due to its simple fabrication, is one of the most common closing loops used.[1,5].According to Faulkner the ordinary vertical loops are extremely sensitive to small changes in the amount of activation[5]. The helices and gabling in vertical loops make them less sensitive to minor manufacturing and placement errors than the standard vertical loops.[5]

Due to the variability of the dental arches, the anterior retraction arch with loops is usually

formed chairside. The formed arch wire is assessed visually before insertion and cannot be away from asymmetries in loop form. Proffit explained the effects of loop dimensions and form on its force production behavior. [12]

The finite element method (FEM) subdivides a system into individual components or 'elements' whose behavior is readily understood and enables one to rebuild the original system so that its behavior can be understood.[13] The FEM has been used to study a number of different problems in orthodontics.[14-20]

The aim of this study was to assess the effects of different loop forms in continuous arch technique on its force characteristics in the anterior retraction arch wires.

Material and Methods

Six 3D finite element models were designed of an anterior retraction arch wire formed and included four average sized anterior brackets and the palatal wall of the bracket slot of the canines. (Fig 1) The models were similar except for the height and width of the loops. The left side loop was kept constant in all stages of the study (height = 5 mm; vertical legs distance = 1 mm)) while modifying the right side loop height (0.5 mm, 1.0 mm, and 2.0 mm)or vertical legs angulations (6 degrees, 12 degrees).

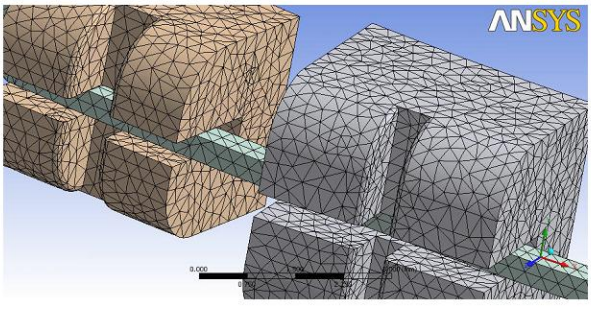

Figure 1: A close view of the meshed model.

SolidWorks 2006 (300 Baker Ave. Concord, Massachusetts 01742, USA) was selected for the modeling phase. The next phase was to transfer the models to the ANSYS Workbench Ver. 11.0 (ANSYS Inc. Soutpointe, 275 Technology drive, Cononsburg PA 15317, USA). All the materials were presumed elastic, homogeneous and isotropic. All the solid bodies were made of Stainless steel with Young's Modulus of 2.0 e-5 MPa and Poisson's Ratio of 0.3. The elastic modulus and Poisson's ratio of the materials were defined. Models were meshed, between 378756 nodes; 46675body elements (10-node-quadratic tetrahedron). (Fig 2) As boundary condition, the posterior segments of the arch wire were restricted from vertical displacement and the bracket bases were also restricted from displacements in all 3 axes. Force findings were assessed in all 6 bracket bases. The end parts of the arch wire were displaced 1 mm distally simulating arch wire activation. Mesializing force on molars, retraction forces on anterior teeth and medially directed forces on canines in both sides have been considered.

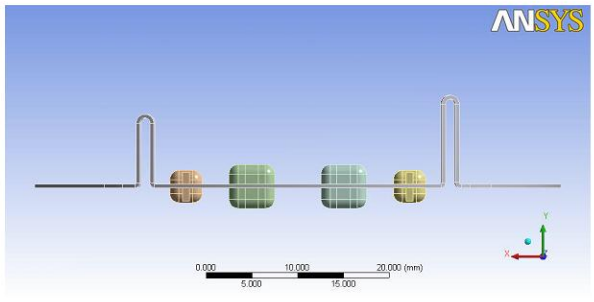

Figure 2a: The patient's left side loop legs are larger while the other side loop kept normal.

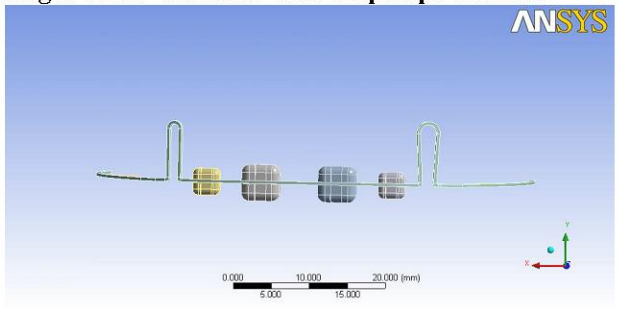

Figure 2b: The patient's left side loop legs are divergent while the other side loop kept normal.

Result

Results are divided into two separate parts according to the approaches:
Different loop heights:
a-1: Anterior retraction force: 0.5 mm of loop height difference caused a 1.54 N of force difference between the left (4.78 N) and right(3.24 N) side.
a-2: Anterior retraction force: 1.0 mm of loop height difference corresponds to a 1.94 N of force difference between the left (4.77 N)and right (2.83 N) side.
a-3: Anterior retraction force: 2.0 mm of loop height difference results in a 2.19 N of force difference between the left (4.77 N) and right (2.19 N) side.
b-1: Medial force on canines: 0.5 mm of loop difference caused a 0.78 N of force difference acting on canines.(2.37 N and 1.59 N)
b-2: Medial force on canines: 1.0 mm of loop difference caused a 0.99 N of force difference acting on canines.(2.37 N and 1.38 N)
b-3: Medial force on canines: 2.0 mm of loop difference caused a 1.3 N of force difference acting on canines.(2.36 N and 1.06 N)
Different legs divergence
c-1: Anterior retraction force produced by symmetric loops was 4.77 N that reduced to 2.75 N with 6 and 12 degrees of vertical leg divergence. The force was almost the same with 6 and 12 degrees of leg divergence.
c-2: The medially directed force vector on canines in a symmetric loop arch was 2.36 N which was reduced to 1.28 N with 6 and 12 degrees of vertical leg divergence .

Discussion

Loop characteristics and the effects of different loop dimensions on its force behavior have been explained.[12] One of its applications is in the anterior retraction ach wires where two loops of the same kind are fabricated to act symmetrically to retract the anterior teeth harmoniously. Their differences in shape and dimension can affect its function directly.
The difference between two loops is important both in an anterior retraction arch wire and in two consequent arch wires in a patient. In anterior retraction arch wire, the loops are supposed to function in the same manner with same force system. In this way, the teeth are hoped to move suitably. When we change a wire containing a loop, we are supposed to make the same loop dimensions to continue the force system started in the previous arch wire. Making a new loop design means a new force system that brings about new force and moments which can be harmful to teeth involved.
Loop form and height was assessed in this study to show their effects separately. According to the results, loop height in one side cannot affect the other side loop force characteristic directly. It can be due to the friction present between bracket slots and the arch wire and the arch form in the anterior part of the dental arch. There may be other results in clinic due to some degrees of wire sliding which can bring complicated force systems in the anterior teeth.
A gradual increase of the force difference between two side of the anterior retraction arch wire is shown which starts at 1.308 N in 0.5 mm of difference and ends at 2.194 N at 2 mm of difference (= 59.6%)(figure-4).

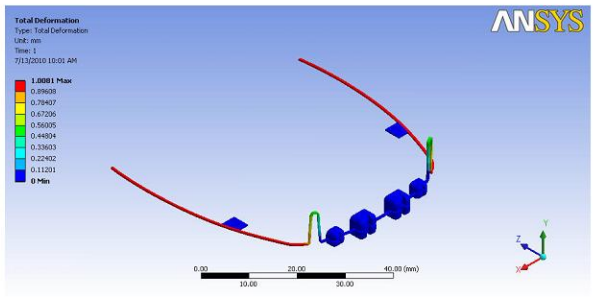

Figure 3: The overall shape of the models in retraction.

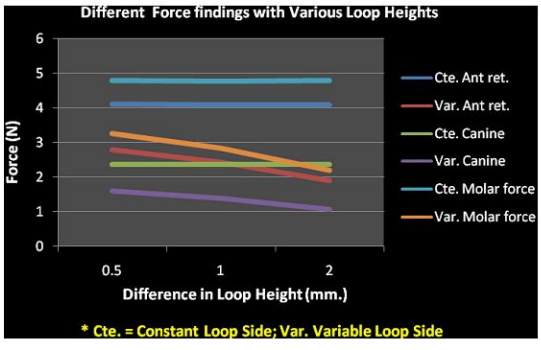

Figure 4: Force Findings in different loop heights.

The mesializing force on molar is also increased with almost the same manner; starting at 1.53 N with 0.5 mm of loop difference and reached 2.58 N at 2 mm of difference (=59%). These findings are in accordance with Proffit and colleagues [12]
The other findings related to loop leg divergence shows a difference between two sides but the differences are almost the same with varying degrees of divergence. Although the forces are not the same in both sides but the difference remained almost constant.(figure -5)
In the end, it is worth mentioning that the force difference between two sides caused a moment which may be the reason for some asymmetries in overjet reduction that is interpreted as the variation of reactions in body halves which seems to be a simplistic explanation. There are situations that we deal with an asymmetric form and accept its side effects but we cannot imagine a symmetric form to be ended in an asymmetric one due to an inaccurate design and loop fabrication. This study showed the importance of loop harmony in an anterior retraction arch wire.

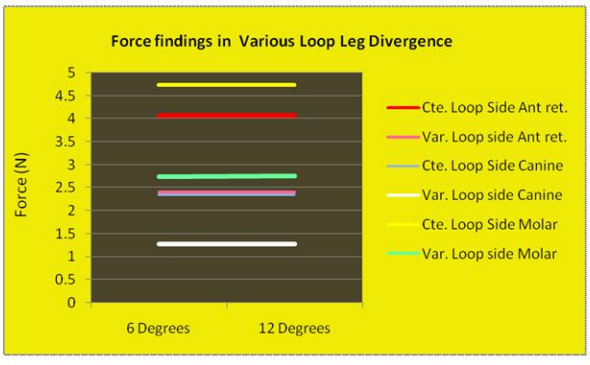

Figure 5: Force Findings in different degrees of loop legs divergence.

Conclusion

Arch wires may seem to be symmetric but act asymmetric. Difference in anterior teeth retraction may be due to some asymmetries in arch wire fabrication which needs further considerations.

Reference

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