ORIGINAL ARTICLE

AJO-DO

Photoelastic analysis of stress distribution in mandibular second molar roots caused by several uprighting mechanics

André Felipe Abrão,[a] Rafael Golghetto Domingos,[a] João Batista de Paiva,[a] Dalva Cruz Laganá,[b] and Jorge Abrão[a]
São Paulo, São Paulo, Brazil

Introduction: Mandibular molar uprighting is indicated when mesial inclination of the second molars occurs because of missing first molars. There are many methodologies to perform such movement. In this study, we aimed to analyze and compare the stress distributions in different molar uprighting techniques. **Methods:** Four photoelastic models were designed to evaluate different mandibular second molar uprighting techniques: a miniscrew positioned in the retromolar region, a beta-titanium alloy cantilever spring, a beta-titanium alloy wire with a T-loop spring, and an 0.018-in stainless steel archwire with an open-coil spring between the second premolar and the second molar. **Results:** On the miniscrew test specimen, the greatest concentration of strains was observed in the cervical zone of the distal root. The cantilever spring had many strains in the cervical zone of the mesial root. On the T-loop spring test specimen, mainly the observed strains were in the apical zone of the mesial root. The open-coil spring specimen showed fringes in the cervical zone and the apical zone of the mesial root without formation of large sequences of strains. **Conclusions:** The miniscrew mechanical action had the least and the cantilever spring mechanical action had the greatest strain means on the roots of mandibular second molars. (Am J Orthod Dentofacial Orthop 2018;153:415-21)

One frequently encountered situation in adult patients is the mesial inclination of mandibular molars; it may be caused by early loss of a deciduous or permanent molar, or agenesis.[1] This inclination can cause periodontal problems and extrusion of the antagonist tooth. A traumatic occlusion may be a consequence, due to premature contacts caused by interferences in centric relation and mandibular excursive movements. Oral rehabilitation in these patients is more difficult,[2,3] and molar uprighting is indicated. This orthodontic movement is useful and necessary because it allows for better distribution of occlusal forces parallel to the long axes of the teeth. As a result, it minimizes side effects such as vertical bone defects, promoting improvement in the injured periodontal tissue in the inclined teeth as well as space recovery for prosthetic oral rehabilitation.

The following are several mechanical techniques for uprighting these teeth: box spring,[4] T-loop spring,[5] helicoide spring,[6] tipback spring,[3] distal jet,[7] simple technique for molar uprighting,[8] open-coil spring,[2] cantilever,[2,9] and miniscrew.[10-12]

One possibility for studying the effects caused by mandibular molar uprigthing is photoelasticity, considered a technique based on birefringence—an opti-mechanical property of transparent polymers.[13] This is an experimental method used in various studies in orthodontics that analyzes the stress and strain fields of structures in the areas of compression and traction.[14-20]

Although uprighting is frequently performed by orthodontists, it is difficult to find studies in the literature that have examined the effects of the stress produced in periodontal tissues on teeth in response to mandibular second molar uprighting. For this reason, we aimed to

From the School of Dentistry, University of São Paulo, São Paulo, Brazil.
[a]Department of Orthodontics.
[b]Department of Prosthodontics.
All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES-DS). CAPES-DS provided the scholarship for the PhD degree of A.F.A.
Address correspondence to: André Felipe Abrão, Av. Prof. Lineu Prestes, 2227, Cidade Universitária, São Paulo 05508-900, SP, Brazil; e-mail, andreabrao@usp.br.
Submitted, May 2017; revised and accepted, July 2017.
0889-5406/$36.00

https://doi.org/10.1016/j.ajodo.2017.07.023

Fig 1. The miniscrew test specimen.

Fig 3. The T-loop spring test specimen.

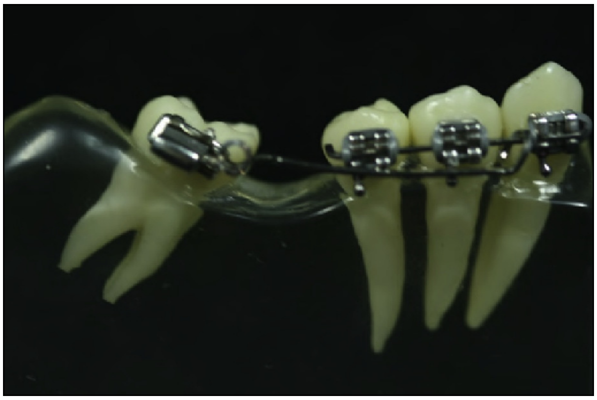

Fig 2. The cantilever spring test specimen.

Fig 4. The open-coil spring test specimen.

analyze and compare the stress distributions in the following 4 molar uprighting techniques using photoelasticity: miniscrew, cantilever, T-loop spring, and open-coil spring.

MATERIAL AND METHODS

In this study, 4 artificial models made from flexible epoxy resin, artificial teeth, and a miniscrew were used. To produce them, a typodont was built with wax and artificial teeth, simulating the clinical situation of a mandibular hemiarch in an adult with a missing first molar and mesial inclination of the second molar. Then an impression of this typodont was taken with silicon (Moldflex Products, São Paulo, Brazil); afterward, the artificial teeth (Orto-Art, Piracicaba, Brazil) and miniscrew (Neodent, Curitiba, Brazil) were positioned in the silicone impression. A flexible epoxy resin was poured into this impression (Epoxi Glass, Diadema, Brazil). In model 1, a miniscrew was positioned in the retromolar region. An orthodontic button was bonded to the mesial aspect of the mandibular second molar, and force was applied with an elastic power chain that was loaded from the screw to the molar (Fig 1). In model 2, brackets were bonded to the premolars and second molar, and a 0.019 × 0.025-in stainless steel archwire was used as an anchorage system; also, a 0.019 × 0.025-in beta-titanium alloy cantilever spring was inserted into the mandibular second molar and supported on the segmented arch between the premolars (Fig 2). In model 3, brackets were bonded to the premolars and second molar, and a 0.019 × 0.025-in beta-titanium alloy wire with a T-loop spring was used (Fig 3). In model 4, brackets were bonded to the premolars and second molar, and an 0.018-in stainless steel archwire with an open-coil spring between the second premolar and second molar was used (Fig 4). A moment of force diagram of each type of mechanics (Fig 5) describes the expected movement for these 4 scenarios.

The isocrometric fringes were observed in a circular polaroscope. The lack of initial stress induced in each model was verified before the tests. Force intensities of 50, 100, 150, 200, 250, and 300 g were applied. After each activation, photographs were taken; then the