Retrospective evaluation of treatment time and efficiency of a predictable cantilever system for orthodontic extrusion of impacted maxillary canines

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Introduction: Orthodontic extrusion of impacted maxillary canines requires careful biomechanical planning and the use of physiologic force. The aim of this study was to evaluate the time needed for orthodontic extrusion of impactions of different severities, using a device that can predictably apply forces under 0.6 N. **Methods:** Twenty-two patients who were consecutively treated were selected retrospectively, and a total of 30 impacted canines were studied. Indexes of impaction were used to measure severity on pretreatment panoramic radiographs. Statistical analysis was used to detect interactions between treatment time, complexity of impaction, age, and sex. **Results:** Treatment time was highly dependent on the patient's age; the shortest treatment time was observed in 11- to 12-year old patients. On the other hand, the severity of impaction had no effect on treatment time. **Conclusions:** Applying physiologic force with the proposed device resulted in a short treatment time, which depended on the patient's age more than the impaction complexity. Few complications were associated with use of this device. Future prospective studies are needed to replicate these findings and confirm the recommended use of this device. (Am J Orthod Dentofacial Orthop 2018;154:55-64)

Maxillary canines can be subject to eruption anomalies in about 2% of the population.[1,2] In 85% of these patients, the maxillary canines are displaced palatally; in 15%, they are buccally displaced.[1] The displacement of maxillary canines is bilateral in 17% to 45% of the all patients.[2] The male:female ratio is about 1:3.[2] In a study of the Italian population, the authors reported a prevalence of palatally displaced canines of 2.4%, of which 34% were bilateral; the male:female ratio was 1:3.[3]

The etiology of maxillary canine impaction can be ascribed to either genetic or environmental factors (obstacles along the eruptive path, soft tissue lesions, or developmental pathologic entities); the latter is considered the most important.[4] An untreated impacted tooth may have the following sequelae: (1) labial or palatal malpositioning; (2) migration of the neighboring teeth and loss of arch length; (3) internal resorption or external root resorption of the impacted tooth and the adjacent teeth; (4) dentigerous cyst formation; (5) infection, especially when the tooth is partially erupted; (6) referred pain; and (7) combinations of these sequelae.[5]

Orthodontic treatment of impacted maxillary canines is often challenging because several points must be considered: (1) careful selection of surgical technique and orthodontic traction modality are essential to achieve satisfactory periodontal health and esthetic results, (2) additional space in the arch needs to be recovered to allow for the canine to align in the arch, (3) accurate anchorage preparation is needed, and (4) the treatment of the impaction must be encompassed in treatment planning of the whole malocclusion.[6-9] The surgical technique for canine exposure should be determined by the orthodontist from the several options that are available. Each patient should be evaluated and the appropriate surgery procedure selected.[10,11]

Treating a malocclusion with an impacted canine usually requires a longer time than the treatment of a similar malocclusion without an impaction.[12] Depending

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on the position, angulation, and vertical height of the impacted canine, longer and more difficult orthodontic management should be expected.[12-14] Treatment time is even longer if the patient is an adult.[6] Negative effects of prolonged orthodontic treatment are well described and include an increased risk of root resorption[15] and a detrimental effect on patient compliance; mechanical eruption appears to accelerate root resorption of neighboring teeth.[16] Therefore, improving the efficiency of treatment for impacted maxillary canines has great clinical importance.

One key factor to achieving clinical success is the planning of orthodontic traction. Several methods can be used (cantilever, power chain, ligature wire, springs, double archwire), but careful biomechanical planning is required to prevent root contact, not to burn anchorage, and to respect the periodontal health of the involved teeth.[17] In addition, the magnitude of the force used should be in a physiologic range and should not exceed 0.6 N.[5] Interestingly, when quantifying the force applied by 3 commonly used systems for orthodontic extrusion of impacted canines—Kilroy spring, elastomeric chain, and ligature wire—Yadav et al[18] found that these 3 systems produced excessive forces of about 2.5 N, far beyond the physiologic limit. In a previous study, a cantilever system with a simple design and adequate force level was presented.[19]

The purpose of this cohort study was to evaluate the time needed for orthodontic extrusion of palatally impacted maxillary canines in relation to the initial position of the canine and the patient's age and sex, applying a physiologic force of about 0.6 N using a simple, predictable, and easy-to-manage system. The null hypothesis was that these variables have no effects on time needed for orthodontic extrusion with the appliance.

MATERIAL AND METHODS

Twenty-two patients consecutively treated for impaction of maxillary canines, from January 2007 to December 2015, were selected retrospectively. All patients who were treated during this period at the dental clinic, Section of Orthodontics, Department of Biotechnological and Applied Clinical Sciences, University of L'Aquila, L'Aquila, Italy, and who met the following inclusion criteria, were included in the sample: (1) unilateral or bilateral impaction, with a palatally displaced maxillary canine; (2) need for orthodontic treatment with fixed appliances; (3) no systemic diseases that could modify the bony metabolism and the biologic response to orthodontic forces; and (4) at least 1 year of posttreatment follow-up.

Sample size calculation for the chi-square test of independence ($\alpha = 0.025$; $1\text{-}\beta = 0.95$; effect size $w = 1.41$, calculated from a pilot study) using G*Power software version 3.1.9.2[20] showed a minimum sample size of 16 patients.

The presence of a canine impaction was assessed by clinical and radiologic examinations. Overretention of the deciduous canine, absence of a labial bulge, and lack of space in the arch were used for the diagnosis of canine impaction, in addition to a radiographic evaluation (using the tube-shift technique). Four indexes, according to the criteria proposed by Ericsson and Kurol[1] and Stivaros and Mandall,[13] were then assessed and recorded by the same operator (M.T.) on the pretreatment digital panoramic radiograph for each impacted canine (Fig 1).

1. The angle (α angle) between the long axis of the impacted canine (a line crossing the root apex and the cusp tip) and the midline (a true vertical line passing through the anterior nasal spine), measured with ImageJ software (National Institutes of Health, Bethesda, Md)[1,21]: the angle was graded 1 if it was between 0° and 15°, 2 if between 16° and 30°, or 3 if greater than 30°.[13]
2. The height of the canine crown in respect to the cementoenamel junction of the lateral incisor: grade 1 was if the canine cusp was occlusal to the cementoenamel junction of the lateral incisor; grade 2 was if the canine cusp was apical to the cementoenamel junction but below half of the root; grade 3 was if the canine cusp was at the apical half of the lateral incisor root; and grade 4 if the canine cusp was higher than the lateral incisor's apex.
3. The amount of overlap of the canine crown over the lateral incisor: grade 1, if there was no overlap; grade 2, if the canine overlapped the incisor by less than half of the incisor root width; grade 3, if the canine covered more than half of the incisor root width; and grade 4, if there was complete overlap of the lateral incisor width.[13]
4. The position of the canine crown in sectors 1 to 5.[1]

In some cases, additional radiographic examinations were prescribed to better assess the 3-dimensional position of the impacted teeth. Each patient had a full orthodontic checkup comprising dental casts, cephalograms, and intraoral and extraoral photographs.

After diagnosis and treatment planning, and obtaining the patient's informed consent, alginate impressions were taken to construct the cantilever. The appliance was made of 2 molar bands for the maxillary first molars, connected by a fixed transpalatal bar with a distal loop.