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ORIGINAL RESEARCH

Evaluation of Periodontal Changes Adjacent to Extraction Sites during Upper Canine Retraction

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ABSTRACT

Introduction: There is an intimate relationship between orthodontic therapy and the periodontal changes that occur during tooth movement.

Materials and methods: This prospective clinical trial aims at investigating the movement of both the free and attached gingiva, as well as the movement of the alveolar bone in the extraction site of the upper 1st premolars during the retraction of the upper canines. In this study, 17 patients (10 female, 7 male) requiring 1st premolar extraction before orthodontic tooth movement were selected and treated at the Department of Orthodontics in the Faculty of Dentistry in University of Hama, Hama, Syria. The upper 1st premolars were extracted, and the implant AutoTacs were applied on the alveolar bone afterward. Then, measurements between the center of the implant AutoTacs and the L-shape wire were taken, utilizing digital Vernier caliper. After 3 weeks of extraction, tattooing marked points were placed on the free and the attached gingival, and the measurements were taken using the same digital Vernier caliper. Closed coil springs made of nickel-titanium were used to retract the upper canines, and a force of 150 gm was applied.

Results: The results of this study showed significant differences between the movement of both the free and attached gingiva and the movement of the corresponding upper canines ($p < 0.001$). The movement of the free gingiva had formed about 77% of the amount of the movement of the upper canine retraction. No significant differences were detected between the place of implant AutoTac X1 and the L-shaped wire (W) during the retraction of the upper canine. On the contrary, significant differences were noticed between the place of implant AutoTac X2 and the L-shaped wire (W) during the retraction of the upper canine ($p < 0.001$).

Conclusion: There is significant movement of hard and soft tissues during and after premolar extraction and orthodontic therapy.

Clinical significance: The movement of supporting tissues of the teeth along with the alveolar bone during canine retraction is an important biological characteristic of the orthodontic tooth movement. Clinicians need to understand the role and importance of the supporting tissues during orthodontic treatment, which needs to be incorporated into their routine clinical evaluations.

Keywords: Orthodontic, Periodontal, Prospective clinical trial.

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INTRODUCTION

During orthodontic therapy, often a premolar is extracted if space is inadequate to orthodontically move the dentition into an ideal arch form. Extractions for orthodontic considerations are treatment planned to improve the facial esthetics and the maintenance of a harmonious occlusion. This is a frequent scenario in the treatment plan of orthodontic therapy. de Castro[1] stated that when 1st premolars are removed the transitions are abrupt in the anterior segment but when second premolars are removed, the transitions are gradual. However, discussion regarding changes of soft and hard tissue after premolar extractions and orthodontic movement comes into question. Numerous articles have described the healing response and physiological changes that occur after a tooth is extracted.[2,3]

Schropp et al[4] described immediate changes that occur after tooth extraction and described new tissue formation in fresh extraction sockets. In the same study, it was observed that there were no appreciable soft tissue alterations at the mesial and distal aspects of the teeth adjacent to the extraction site. During the first 3 months following tooth extraction, pocket reduction of approximately 1 mm was obtained. Mean gingival recession of 0.7 mm occurred gradually during the 12-month healing period. These results indicate that periodontal health could be altered – gingival recession occurred at the teeth adjacent to an extraction site during the healing period.

Potential periodontal outcomes of orthodontic therapy include bone loss, recession, and/or apical migration of the gingival margin location.[5] Additional soft tissue changes include gingival clefts, between the papilla on either side of the premolar extraction site and the compressed epithelium overlying the tooth socket.[6] Histologically, the gingival clefts consist of fibrous connective tissue covered by a layer of stratified squamous epithelium. No clefts were noted in premolar areas of a comparable population without previous orthodontic treatment. The authors concluded that the presence of the gingival clefts appears to have clinical implications, both in orthodontic relapse and maintenance of gingival health. Gingival invaginations display hyperplastic changes including epithelial hyper keratinization with pronounced depth proliferation at the edges of the invagination.[7-9] Stimulation from the orthodontic forces has been reported to be responsible for the hyperplastic tissue reaction.[10] Malkoc et al[11] attributed these histological changes to the interruption of the continuity of the gingival fiber system and bone remodeling that occur with destruction of the cortical plates, socket healing, and root movement.

The etiology of invagination is not completely understood. The specific aim of this study is to evaluate the impact of orthodontic tooth movement after 1st premolar extraction through an extraction site on the periodontium.

MATERIALS AND METHODS

Study Design and Study Sample

A prospective clinical trial was conducted at the Orthodontics Clinic, University of Hama, Dental School, Syria, and was approved by the University of Hama, Dental School Research Ethics Committee.

This study was done on 17 patients (7 males and 10 females, aged 14–24 years; mean age: 15 years 8 months) who required 1st premolar extraction with subsequent space closure for orthodontic therapy. The sample size was conducted using Minitab, version 15 (Minitab, State College, Pennsylvania). Using paired-samples t-tests with an alpha level of 0.05 and a power of 80% and assuming that the smallest difference requiring detection in canine retraction was 0.5 mm, a sample of 16 subjects was required.

Patients' Recruitment

An evaluation of patients referred to the Department of Orthodontics for treatment was performed. Those patients who had been scheduled for premolar extraction to facilitate canine retraction were included if they had met the following inclusion criteria: (1) Class II division 1 and 2 malocclusion (Angle's); and an ANB angle above 5°; (2) treatment planned for upper 1st premolar extraction with subsequent orthodontic space closure; (3) permanent dentition with an age range of 14 to 24 years; (4) leveling and aligning of upper dental arch completed; (5) good general health with no diseases that would contraindicate local anesthesia; (6) the absence of craniofacial syndromes, cleft lip or palate, or previous dentofacial trauma; (7) good oral hygiene with no periodontal disease in the upper jaw; (8) the absence of canine restorative or endodontic treatment; (9) the absence of structural or morphologic canine abnormalities; and (10) no previous orthodontic treatment.

The research project was explained and information sheets about the proposed trial were given. On acceptance to participate, informed consents were obtained. Orthodontic evaluation and records, including study models, lateral cephalometric radiograph, panoramic radiograph, and intraoral and extraoral photographs were obtained. Once the patients were enrolled, informed consent was obtained and a referral was completed for premolar extraction.

Data Collection Methods

All subjects were treated with preadjusted fixed appliances on the upper arch, with 0.022- to 0.028-inch slot brackets (MBT Prescription, American Orthodontics, Sheboygan, Wisconsin). A conventional anchorage protocol was used (i.e., transpalatal arches soldered to the 1st upper molars bands).

Leveling and alignment were performed using a sequence of arch wires. After insertion of a 0.019 to 0.025 stainless steel wire, the upper 1st premolars were extracted. The orthodontic treatment, periodontal evaluation, and subsequent extractions were performed by the same principal researcher.

Surgical Procedures

A traumatic extraction with gingival mucoperiosteal full-thickness flap was raised to expose cortical bone on the buccal side of the upper right and left canines. Sockets

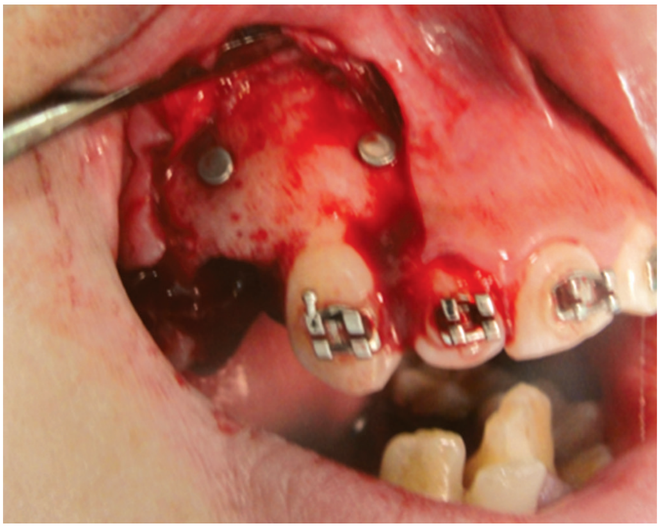

Fig. 1: AutoTac implant placed on the right side

Fig. 2: AutoTac implant placed on the left side

walls and buccal plate were preserved during each extraction. Sockets were debrided with a bone curette, irrigated with sterile saline, and hemostasis was obtained with gauze and light finger pressure.

Immediate postextraction procedures included the following:

Placing the AutoTac implant (pins of titanium alloy), the proprietary delivery handle drives titanium alloy tacks by applied light force on the alveolar bone between upper canine and lateral roots, mesial and distal to upper canine root in the same horizontal level at 4 mm from the cementoenamel junction of upper canine in vertical direction (Figs 1 and 2).

AutoTac is a membrane system that allows fix membranes effectively by simply pressing a button. The patented handle places the pins of titanium alloy that will stabilize the membrane during the healing process.

Medical devices consist of, namely, a medical tack delivery system comprising a tack delivery device and a plurality of tacks; a medical tack delivery kit comprising a tack delivery device, titanium tacks, a tack holder, and forceps; a medical tack delivery kit comprising a tack delivery device, resorbable tacks, a sterilization tray, a cortical drill, and a drill guide. Singe X1 was given to the center of tacks which was placed between roots of canine and lateral. Singe X2 was given to the center of tacks which was placed distally to roots of canines in right and left sides. The mucoperiosteal flaps were sutured with absorbable surgical sutures. A review of postextraction instructions was completed verbally and in writing with patient (and parent/guardian if appropriate). To differentiate the right and left sides on the lateral cephalogram, a 0.0175 × 0.025-inch stainless steel wire in an L-shape with 0.5 cm of vertical length and 1 cm of horizontal length was placed in the buccal tube of 1st upper molars[11] and given W singe. The right and left canines were identified by tracing them along the arch wire from the respective molars to the arch wire-bracket junction in the canine bracket. Measured the distance between the X1 and the stainless steel wire in an L-shape placed in the buccal tube of upper 1st molars (W), and X2 to W was measured intraorally using a digital caliper and strain gauge.

Application of BioTouch MicroPigments on Gingiva

BioTouch pigments are formulated with iron oxides, which are known to be safe for cosmetic use, colorants, and micropigmentation to the face and body. Because pigments have more of these particles in every drop, they absorb into the skin much more effectively. The result is less fading and truer color.

MicroPigments: BioTouch MicroPigments are nondrying, rich, natural colors formulated with superfine particles and iron oxides for easy absorption into the skin. BioTouch tattoo machine kit includes sterilized needle caps, front casing, transmission shaft, and an assortment of precision post round and flat needles in various prong sizes. In addition, machine, AC adapter, lubricant, an optional foot pedal also available for hands-free speed control, powerful rotary motor, 10,000 rpm, providing ultra-smooth, noise-free operation, and instruction manual. After 3 weeks of extraction, tattooing marked points were placed on the free and attached gingiva using BioTouch MicroPigments tattoo machine. Four tattooing marked points on the buccal surface of free gingiva from lateral, canine to free gingiva between upper second premolar and upper 1st molar in the same horizontal level (Figs 3 and 4) were placed. Singes are given as a1, a2, a3, and a4 to the four tattooing marked points on the buccal surface of free gingiva from lateral canine to free gingiva between upper second premolar and upper 1st molar.

Fig. 3: Application of BioTouch MicroPigments on free and attached gingiva (R)

Fig. 4: Application of BioTouch MicroPigments on free and attached gingiva (L)

Fig. 5: Canine retraction (R)

Fig. 6: Canine retraction (L)

Three tattooing marked points on the buccal surface of attached gingiva from canine to attached gingiva of upper second premolar were placed. Singes are given as b1, b2, and b3 to three tattooing marked points on the buccal surface of attached gingiva from canine to attached gingiva of upper second premolar. The distances between these tattooing marked points are measured using a digital caliper before starting upper canine retraction. The distance between tattooing marked point (a4) on the free gingiva and tattooing marked point (b3) on the attached gingiva to the L-shape placed in the buccal tube of upper 1st molars (W) was measured. The distance between the point (C) tip of the upper canine and the point (M) tip of mesiobuccal cusp of the upper 1st molar using a digital caliper before starting upper canine retraction in the right and left sides was also measured. Orthodontic forces for upper canine retraction were applied 15 days after tattooing marked points placement (Figs 5 to 7). Nickel-titanium closed coil springs with a force of 150 gm (measured with the Dontix gauge; American Orthodontics, Sheboygan, Wisconsin) were stretched between the canine and the molar on 0.019 to 0.025-inch stainless steel arch wires. Sets of measurements were taken; the 1st was before canine retraction and others when canine retraction was started

Fig. 7: Occlusal view

Fig. 8: Lateral view of the teeth showing the canine retraction is completed

Fig. 9: Frontal view of the teeth showing the canine retraction is completed

in accordance with the patient's treatment plan according to the following schedule:

T0: Before canine retraction (start of retraction); T1–T6: Monthly recall visits from 1st to 6th month and T7: Complete space closure. Once space closure at each site was started, periodontal changes were measured again at the teeth adjacent to the former extraction site. All space closure measurements were completed by a single examiner (Figs 8 and 9). Gingival invaginations were recorded when present in this study. The interdental soft tissue was clinically assessed and evaluated for the presence of gingival invagination using transgingival probing. Application of a lower fixed appliance was postponed until completion of the canine retraction procedure on the upper jaw.

Statistical Analysis

The data were entered into the Statistical Package for the Social Sciences (SPSS 22.0; SPSS Inc., Chicago, Illinois, USA) for Windows. A paired-sample t-test was completed to compare the clinical parameters by tooth site and to compare pre- *vs* postcanine retraction measurements, with a statistical significance of $p < 0.05$, parametric (two-sample t-test) or nonparametric (Mann–Whitney U-test) were used as appropriate to detect significant differences between the two measurements with the level significance at 0.05. Pearson's correlation coefficient was used to study the degree of correlation between measurements.

Error of the Method

The error of the measurement method was calculated from double measurements of five randomly selected tooth movement measurements using Dahlberg's formula.[12] The measurement was repeated after a 30-minute interval for the selected patients. The error of the method was between 0.18 and 0.14 mm and was considered low. No systematic error was detected using the paired t-test. The intraclass correlation coefficient confirmed the high reliability of the measuring procedure ($r = 0.992$).

RESULTS

Seventeen patients completed the entire study, including upper 1st premolar extraction, pre- and postperiodontal measurements, and orthodontic therapy. In total, 34 premolar teeth were extracted in preparation for orthodontic therapy. Of the 17 subjects, 7 were males and 10 were females, mean age 15 years 8 months. The canines were successfully retracted in all subjects. Canine retraction was considered complete when the extraction space was closed. There is a significant difference between the movement of free gingiva and retraction canine movement during all times of measurements (Table 1). There is a significant difference between the movement of attached gingiva and retraction canine movement during all times of measurements (Table 2). There is correlation between free and attached gingiva movement and movement of upper canine during all times of measurements. These changes are statistically significant. There is no significant difference between free and attached gingiva during canine retraction at 1st and 2nd measurement (T1–T2) where $p = 0.533$ at T1 and $p = 0.082$ at T2, but there is significant difference between free and attached gingiva during another measurement (T3–T7) where $p \leq 0.001$ (Table 3). There is no significant difference in the position of point a4 on free gingiva in relation to wire in an L-shape at the buccal tube of 1st upper molars (W), $p = 0.772$ (Table 4). There is no significant difference in the position of point b3 on attached gingiva in relation to wire in an L-shape at the buccal tube of 1st upper molars (W), $p = 0.137$. There is no significant difference between changing the position of AutoTac implants (X1; between lateral and canine) in relation to stainless steel wire in an

L-shape at the buccal tube of 1st upper molars (W) before and after space closure by canine retraction, $p = 0.052$ (Table 5). There is a significant difference between changing the position of AutoTac implants (X2; distal to canine) in relation to stainless steel wire in an L-shape at the buccal tube of 1st upper molars (W) before and after space closure by canine retraction, $p \leq 0.001$ (Table 6).

Gingival Invaginations

Gingival invaginations were recorded when present in this study. In total, 34 extraction sites were evaluated for gingival invagination formation during or after completion of space closure by upper canine retraction. Gingival invaginations were present in 29.7% of the study sites population. The gingival invagination revealed a folding or crease of the tissue. The gingival invaginations were recognized more frequently in males (77.3%) than females.

DISCUSSION

The present prospective clinical trial was undertaken primarily to evaluate periodontal changes adjacent to extraction sites during upper canine retraction. The present findings have shown that the mean rate of canine retraction was 4.75 mm during 7 months which represent the period of study, and the average rate of canine retraction was 0.8 mm per month. These results of rate of canine retraction agree with those from Thiruvenkatachari et al.[13] Those results were similar to ours.

The results of this study showed that the mean rate of free gingiva during canine retraction was 3.69 mm and there is a significant difference between free gingiva movement and retraction of canine during all times of study $p < 0.001$. However, the movement of free gingiva corresponded to the movement of upper canine in terms with differing rate. The movement of free gingiva had formed 77.69% of the amount of the upper canine retraction. These results agree with those from Aboul-Ela et al.[14]

McCollum and Preston[15] noticed during canine retraction, the movement of free gingiva had formed 49.4 to 82.4% of the amount of the upper canine retraction, this is close to the value we obtained.

The results of this study showed that the mean rate of attached gingiva during canine retraction was 3.02 mm and there is a significant difference between attached gingiva movement and retraction of canine during all times of study $p < 0.001$. However, the movement of attached gingiva corresponded to the movement of upper canine in terms with differing rate. The movement of attached gingiva had formed 63.58% of the amount of the upper canine retraction.

These changes in the movement of attached gingiva during canine retraction can be attributed to the proliferation of the gingival tissues, expansion and elongation of gingival tissues, proliferation of fibroblasts, division of connective tissues, and increase in distances between fibers.[12] Ong and Wang[16] compared patients with a history of orthodontic therapy (at least 2 years prior) with subjects who had not had any orthodontic experience. The findings suggested the minimal effects of orthodontic treatment on the periodontium. No significant differences were detected between the place of implant AutoTac X1 (X1 placed on the alveolar bone between lateral incisor and canine) and the L-shaped wire (W) during the retraction of the upper canine during the retraction of the upper canine ($p = 0.052$) throughout all the study periods that indicated absence of alveolar bone movement mesial to canine and the changes existed at the site of extraction on the side of canine retraction. These results agree with those from Graber et al.[17]

On the contrary, significant differences were noticed between the place of implant AutoTac X2 (X2 placed on the alveolar bone distal to the canine) and the L-shaped wire (W) during the retraction of the upper canine ($p < 0.001$) throughout all the study periods that indicated the presence of alveolar bone movement at the site of extraction in the same direction of canine retraction but with different amount, whereas the movement of alveolar bone formed 62.32% of the total amount of canine retraction and in the same direction. The results of the Pearson's correlation coefficient show the existence of a strong, positive correlation between the movement of the free gingiva and the movement of the upper canine retraction, and a moderate, positive correlation between the movement of the attached gingiva and the movement of the upper canine retraction, whereas the correlation between the change in place of the implant AutoTac X2 and the upper canine retraction movement was weak and negative.

Gingival invaginations were present in 29.7% of the study population. The gingival invagination revealed a folding or crease of the tissue. The prevalence of gingival invaginations found in this study is similar to that reported by Robertson et al,[18] who demonstrated that 35% of interdental clefts were associated with premolar extraction and subsequent orthodontic space closure. All subjects were in the retention phase of orthodontic therapy in the study. Therefore, all spaces were orthodontically closed.

Reichert et al[9] also demonstrated that the great majority of clefts were observed in patients with a history of 1st premolar extraction. It was found that no clefts were observed in premolar areas of orthodontic patients who did not require premolar extraction or in patients without previous orthodontic treatment. The publication also conveyed that the anatomical configuration of the cleft

Table 1: Comparison between free gingiva movement and retraction of upper canine

	Comparison between free gingival movement and upper canine movement in (mm)						
	T0–T1 Mean	*T0–T2 Mean*	*T0–T3 Mean*	*T0–T4 Mean*	*T0–T5 Mean*	*T0–T6 Mean*	*T0–T7 Mean*
Canine	0.89	1.68	2.49	3.31	4.1	4.67	4.75
Free gingiva	0.62	1.31	2.01	2.68	3.24	3.63	3.69
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Mann–Whitney

Table 2: Comparison between attached gingiva movement and retraction of upper canine

	Comparison between attached gingival movement and upper canine movement in (mm)						
	T0–T1 Mean	*T0–T2 Mean*	*T0–T3 Mean*	*T0–T4 Mean*	*T0–T5 Mean*	*T0–T6 Mean*	*T0–T7 Mean*
Canine	0.89	1.68	2.49	3.31	4.1	4.67	4.75
Attached gingiva	0.6	1.15	1.71	2.24	2.66	2.94	3.02
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Mann–Whitney

Table 3: Comparison between free gingiva and attached gingiva movement during upper canine retraction

	Comparison between free gingiva and attached gingiva movement during canine retraction (mm)						
	T0–T1 Mean	*T0–T2 Mean*	*T0–T3 Mean*	*T0–T4 Mean*	*T0–T5 Mean*	*T0–T6 Mean*	*T0–T7 Mean*
Free gingiva	0.62	1.31	2.01	2.68	3.24	3.63	3.69
Attached gingiva	0.6	1.15	1.71	2.24	2.66	2.94	3.02
p-value	0.533	0.082	<0.001	<0.001	<0.001	<0.001	<0.001

Mann–Whitney

impaired the patient's ability to keep the area clean and the resultant plaque-induced gingival inflammation was significantly greater in areas manifesting clefts as compared to adjacent noncleft areas in the same arch. The publication concluded that the presence of the cleft appeared to have clinical implications, both in terms of orthodontic treatment with a history of premolar extraction and maintenance of the gingival health.

In addition to the orthodontic appliance, the gingival invagination may impede oral hygiene and prevent plaque removal. This would induce bacterial accumulation that leads to gingivitis especially in patients with poor oral hygiene. Therefore, adequate brushing and flossing at the site of the invaginations are highly recommended to improve periodontal health.

Similar to a food trap, the invagination allows predisposition of plaque accumulation and eventual inflammation. It is an important concept that the patient maintains a healthy periodontal status not only during orthodontic therapy but also during the retention phase of orthodontic therapy. Overall, the gingival invagination could be contributing factor in the disease process, with an adverse effect on the future periodontal status of the site.

However, many subjects still demonstrated invaginations months after completion of active treatment or discontinuation of all orthodontic appliances. This study

Table 4: Point (a4) and point (b3) position changes in relation to stainless steel wire in an L-shape at the buccal tube of 1st upper molars (W)

	T0	*T7*	*p-value*
a4 – W	1.23	1.27	0.772
b3 – W	2.36	2.41	0.137

Paired t-test

demonstrated a high percentage of gingival invaginations in patients who underwent premolar extractions with continuation of orthodontic therapy. Nevertheless, not all subjects in the study had completed active orthodontic treatment, so proper follow-up was not completed. The retention phase was not considered as many of the patients still presented with open contacts at the site of the premolar extraction. There may be alterations of the tissue and remodeling of the sites that may show gradual changes over time.

Limitations include a hard tissue evaluation in the posttreatment measurements. Anesthetizing patients for bone sounding and transgingival probing at post-measurement would have been medically unnecessary and potentially harmful to the patient. In addition, cone beam computed tomography scans were not completed due to potential radiation exposure without patient benefit. There are other limitations within the study that

Table 5: Position of AutoTac implant (X1, X2) changes in relation to stainless steel wire in an L-shape at the buccal tube of 1st upper molars (W)

	Time	*Average*	*Stander deviation*	*Minimum level*	*Maximum level*	*T0–T7*	*p-value*	
X1	T0	20.05	1.159	17.65	22.1	0.23	<0.001[T]	0.052[P]
X1	T7	19.82	1.136	17.34	21.98	0.23		0.052[P]
X2	T0	10.23	1.228	9.67	13.38	2.96	<0.001[P]	<0.001[P]
X2	T7	7.27	1.871	5.86	10.33	2.96		<0.001[P]
CM	T0	18.00	1.34	15.33	19.89	4.75	CM *vs* X1	CM *vs* X2
CM	T7	13.25	1.01	10.98	15.6	4.75	<0.001[T]	<0.001[T]

[P]Paired t-test; [T]Two-sample t-test

Table 6: Correlation between movement of free and attached gingiva, AutoTac implants (X1, X2), and retraction movement of upper canines

Pearson correlation coefficient	*Free gingiva*	*Attached gingiva*	*AutoTac implants X1*	*AutoTac implants X2*
Canine	−0.724	0.638	0.084	−0.274
p-value	<0.001	<0.001	0.637	0.159
	Positive correlation	Positive correlation	Negative correlation	Negative correlation

are important to address due to the potential effect on the resulting outcomes. There were a number of patients that were lost throughout the study due to refusal of orthodontic therapy, failed appointments, or inability to complete measurements. The sample size of 17 was small in comparison to the original population study of 35 participants. Data may have shown statistical results and/or may have detected obvious trends if there had been a larger study population. The appliances not only may impede proper oral hygiene but also create difficulty when measuring all clinical parameters. Such inflammation may induce hyperplasic tissue, which can further inhibit the ideal placement of the periodontal probe. The obstruction of the bracket could have altered an accurate measurement of the sulcus depth.

CONCLUSION

The results convey that there are limited but important changes that occur in the periodontal tissues during and after upper canine retraction. Some patients may be at greater risk for gingival invaginations and after premolar extraction with subsequent orthodontic therapy. Overall, the findings support that there are limited but important changes that could occur in the soft and hard tissue during and after premolar extraction and orthodontic therapy. Alterations of the tissues are not detrimental to the periodontal status during and after active orthodontic treatment.

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