Risk factors contributing to gingival recession among patients undergoing different orthodontic treatment modalities

NOZHA MAHMOUD SAWAN[1,*], AHMED GHONEIMA[2], KELTON STEWART[2], SEAN LIU[3]

[1]Department of Preventive Dental Sciences, College of Dentistry, Princess Nourah Bint Abdulrahman University, Riyadh, Kingdom of Saudi Arabia

[2]Department of Orthodontic and Oral Facial Genetics, Indiana University School of Dentistry, Indianapolis, IN, USA

[3]Private Practice, Kent, WA, USA

*Corresponding author: Nozha Mahmoud Sawan, BDS, MED; Department of Preventive Dental Sciences, College of Dentistry, Princess Nourah Bint Abdulrahman University, 7396 Wadi As Saws, An Nahdah, Riyadh 3804 13222, Kingdom of Saudi Arabia; Phone: +966 5390 88 892; E-mail: nozha.sawan@gmail.com

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Abstract: *Objective:* The aim of this study was to investigate the risk factors contributing to gingival recession among patients undergoing orthodontic treatment. *Methods:* Records of 100 Caucasian patients who completed orthodontic treatment were evaluated before and after treatment. Intercanine and molar widths, arch perimeter, arch depth, and keratinized gingival height were measured for both arches. The association of orthodontic treatment strategy (changing incisal inclination, expansion, and extraction), keratinized gingival height, and various other measurements with gingival recession was evaluated by using generalized linear mixed models with logistic regression analysis. *Results:* For each 1 mm increase in pre- and post-treatment keratinized gingival height, there was 0.77 and 0.51 times lower odds of gingival recession. For each 1 mm increase in post-treatment intercanine width, there was 0.80 times lower odds of gingival recession. And for each 1 mm increase in change in the arch depth, there was 1.16 times higher odds of gingival recession. For each 1 mm increase in pre- and post-treatment mandibular symphysis width, there was 0.47 and 0.39 times lower odds of gingival recession. *Conclusion:* Regardless of the type of orthodontic treatment, increased keratinized gingival height, mandibular symphysis width, and post-treatment intercanine width lower the risk of gingival recession.

Keywords: gingival recession, orthodontic treatment, keratinized gingiva, extraction, odds ratio

Introduction

Gingival recession is defined as the apical displacement of the marginal gingiva relative to the cementoenamel junction (CEJ) that results in root caries, hypersensitivity, and unaesthetic appearance [1, 2]. Multiple factors are considered to contribute to gingival recession. (1) Age-related gingival recession is more prevalent in individuals older than 50 years [3, 4] without gender preference [5–7]. (2) Population-related gingival recession occurs more in Caucasians [3, 4] and in populations without access to dental care [3]. (3) Site-related gingival recession is observed more frequently on the facial surfaces of mandibular central incisors and maxillary first molars [8]. (4) Mechanical factors such as traumatic tooth brushing and bruxism are suggested to initiate or worsen gingival recession [9]. (5) Periodontal conditions such as decreased keratinized gingival thickness and height, reduced alveolar bone thickness as a result of tooth malposition, tapered tooth shape, and presence of dehiscence/fenestration are also common risk factors for gingival recession [10–12].

Orthodontic treatment is considered to be an iatrogenic factor that contributes to gingival recession [11, 13, 14]. Although a well-aligned dentition is favorable for maintaining periodontal health [12], recent systematic reviews support the association between orthodontic treatment and gingival recession [11, 14, 15]. The movement of teeth with thin tissue biotype has been previously investigated using a primate model, demonstrating that extensive bodily movement of teeth resulted in alveolar bone height reduction and an apical displacement of gingiva [13]. This occurs with flaring of incisors to resolve crowding, expansion of dental arches to correct transverse discrepancies, or retraction of anterior teeth to close extraction spaces. Predisposing factors of gingival recession in orthodontic patients are still not clear. Associations between what is thought to be predisposing factors such as age, gender, keratinized gingival height and the different orthodontic treatment modalities (extraction, changing incisal inclination, and (or) changing intercanine and -molar widths) have not been investigated.

With this background, the aim of this study was to investigate the risk factors contributing to gingival recession among patients undergoing orthodontic treatment.

Materials and Methods

Participants

The post-treatment archive at a graduate orthodontic program in a university setting was searched to identify patients who received full comprehensive orthodontic treatment. Patients who are Caucasian and started orthodontic treatment with full permanent dentition (from first molar to first molar in both arches) with complete pre- and post-orthodontic treatment records (orthodontic models, intra-oral photographs, and cephalometric radiographs) were included. Exclusion criteria included patients >50 years old, cigarette smokers, and patient with systemic diseases that affect periodontium (e.g., diabetes and osteoporosis), craniofacial anomalies, orthognathic or periodontal surgery, gingival recession prior to orthodontic treatment, plaque accumulation, and gingival inflammation before treatment and at the time of debonding.

A total of 100 Caucasian patients who were debonded between 2012 and 2014 were consecutively selected (F: $n=77$, M: $n=23$). Pre- (T_1) and post-treatment (T_2) records (dental casts, intra-oral photographs, and cephalomteric radiographs) were evaluated. A time frame of 1–3 years was set for treatment to include patients who were treated between 1 and 3 years. Patient data were deidentified by the primary investigator and no link between collected data and charts was maintained. Patients were categorized into three groups; those who underwent extraction ($n=25$), those who had more than 5° change in incisal angle ($n=43$), and those who underwent arch expansion ($n=32$). Patients' age ranged from 12 to 26 years, with a mean age of 13.5 years.

Cast measurements

The plaster models from (T_2) *(Fig. 1)* were evaluated for the presence of gingival recession for each anterior tooth

Fig. 1. Scoring the presence of gingival recession (Y: yes; N: no)

(maxillary and mandibular, canine to canine). Gingival recession was recorded as nominal data, denoted as either yes or no. Recession was scored as "Yes" if the labial CEJ is exposed. Other cast analyses *(Fig. 2)* were based on standardized occlusal scans for maxillary and mandibular dental models. A color scanner (Aficio MP 3351, Ricoh Americas Corporation, Malvern, PA) with a resolution of 600 dpi was used to obtain standardized scans of the occlusal aspect of each model. The following measurements were computed from the scanned maxillary and mandibular casts: (1) arch depth *(Fig. 2a)*: the distance from a point midway between the palatal surfaces of the central incisors at the embrasure to a perpendicular line drawn from the mesial aspect of the permanent first molars [16]; (2) intercanine width *(Fig. 2b)*: the distance between canine cusp tips; (3) intermolar width *(Fig. 2b)*: the distance between lingual grooves of maxillary first molar, and the distance between central fossae of mandibular first molar [16]; (4) arch perimeter *(Fig. 2c)*: the sum of the distances from the mesial contact points of the permanent first molars to the distal contact points of the canines plus the distances from the distal contact points of the canines to the mesial contact points of the central incisors [16]; (5) crowding or spacing *(Fig. 2d)*: the sum of mesiodistal widths of all teeth mesial to the first molar to the mesial surface of the opposite first molar will be subtracted from arch perimeter. Positive or negative results indicated spacing or crowding, respectively.

All measurements were performed by one trained and calibrated investigator (NMS) using a software program (Dolphin® Imaging 11.5 Premium, Dolphin Imaging & Management Solutions, Chatsworth, CA, USA).

Intra-oral photos assessment

Keratinized gingival height was assessed at the mid buccal aspect of each maxillary and mandibular anterior tooth (canine to canine) from intra-oral photos *(Fig. 3)*. These intra-oral colored photographs were taken with a digital

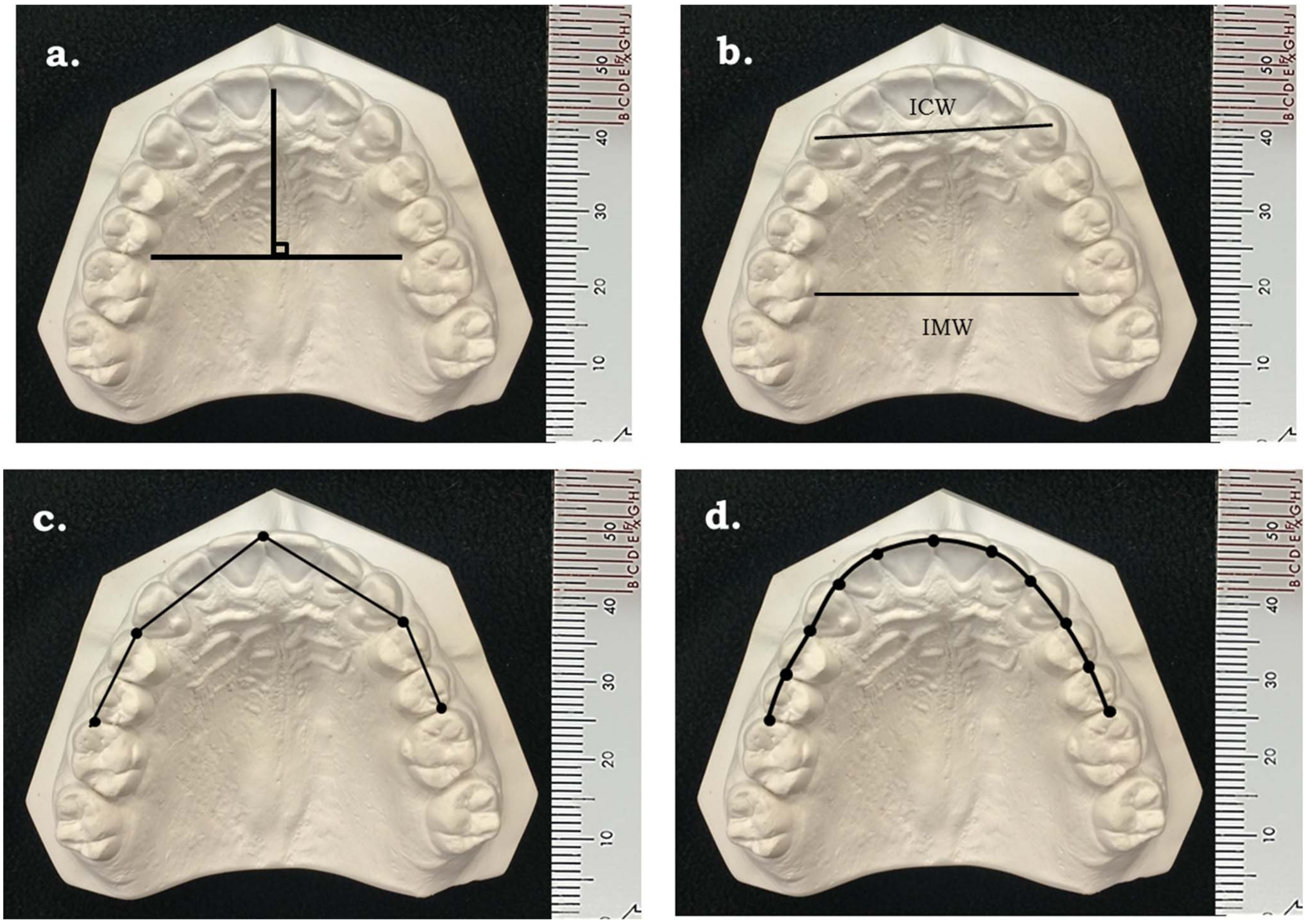

Fig. 2. Cast measurements. (a) Arch width is determined by the distance from a point midway between the labial surfaces of the central incisors at the embrasure to a perpendicular line drawn from the mesial aspect of the permanent first molars. (b) Intercanine width (ICW) is determined by measuring the distance between the canine cusp tips. Intermolar width (IMW) is determined by measuring the distance between central fossae of the first molars. (c) Arch perimeter is determined by measuring the distance from the mesial contact points of the permanent first molars to the distal points of the canines to the mesial contact points of the central incisors. (d) Crowding and spacing were measured by subtracting the sum of mesio-distal widths of all teeth mesial to the 1st permanent molar to the mesial of the opposite 1st molar

camera (EOS, *REBEL* XTi, Canon® Global, Tokyo, Japan). The length and focal length of the lens were EF 100 mm and 2.8 Macro, respectively. The images were obtained at the following settings: Flash ETTL, F-stop @ 32, shutter speed @ 1/60, and ISO @ 200. Each frontal and lateral intra-oral photograph was viewed using Dolphin software. First, each crown length was measured on the cast using an electronic caliper "Pittsburgh6' Digital Caliper" with an accuracy of 0.01 mm. Second, each crown length was calibrated in intra-oral photo using Dolphin® Imaging 11.5 Premium. The height of keratinized gingiva was measured in intra-oral photograph using Dolphin® Imaging 11.5 Premium.

Cephalometric analysis

To measure the change in incisal inclination from T_1 to T_2, the maxillary incisal inclination (the angle formed by the upper incisors and Sella–Nasion line; U1/SN) and the mandibular incisal inclination (the angle formed by the lower incisor teeth and the mandibular plane; L1/MP) were measured. In addition, the mandibular symphysis width was measured as the shortest distance between the anterior and posterior borders of the symphysis *(Fig. 4)*.

Intra-examiner reliability

A single calibrated and trained investigator (NMS) identified landmarks and conducted measurements. Twenty patients were randomly selected and all measurements were repeated after 2 weeks. The intra-examiner reliability was confirmed with the intra-class correlation coefficients ranging from 1 to 0.98 for cast and cephalogram measurements, and from 1 to 0.93 for intra-oral photograph measurements.

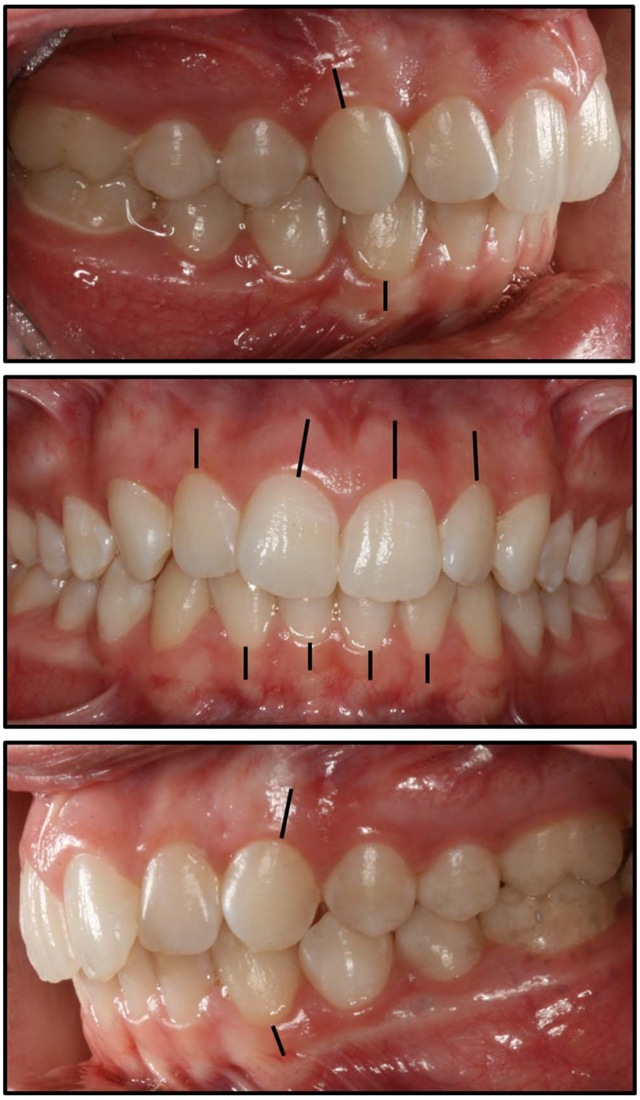

Fig. 3. Pre-orthodontic intra-oral photos showing the keratinized gingival height measurements

Statistical analysis

Power analysis was performed prior to any evaluation. With a sample size of 100 patients, the study has 80% power to detect an odds ratio of 2.5 for predictors that are continuous measurements and odds ratio of 4.5 for predictors that are categorical variables with prevalence of 25%, assuming two-sided tests conducted at a 5% significance level and the percentage of patients with at least one recession is 10%. The association of orthodontic treatment modality (changing incisal inclination, arch expansion, or extraction), keratinized gingival height, patient's age, and patient's gender with gingival recession was evaluated by using generalized linear mixed models with logistic regression analysis.

Results

Summary of mean and standard errors of each predictor is listed in *Table I*. The predictors were evaluated using backward selection, until all predictors remaining in the model were significant ($P < 0.05$). None of the different orthodontic treatment strategies were found significant ($P = 0.058$). As a model, pre-treatment keratinized gingival height ($P < 0.01$), post-treatment keratinized gingival height ($P < 0.001$), post-treatment intercanine width ($P < 0.0001$), and change in arch depth ($P < 0.05$) were found to be statistically significant to gingival recession *(Table II)*. For each 1 mm increase in pre-treatment keratinized gingival height, there was 0.77 times lower odds of gingival recession. For each 1 mm increase in post-treatment keratinized gingival height, there was 0.51 times lower odds of gingival recession. For each 1 mm increase in post-treatment intercanine width, there was 0.80 times lower odds of gingival recession and for each 1 mm increase in change in arch depth, there was 1.16 times higher odds of gingival recession *(Table II)*. An additional model was created by adding the non-extraction variable into the model. Non-extraction treatment gave 1.31 times higher odds of gingival recession *(Table III)*.

Two final models were created for pre- and post-treatment mandibular symphysis widths as they were statistically significant predictors of gingival recession ($P < 0.001$) *(Tables IV and V)*. For each 1 mm increase in pre-treatment mandibular symphysis width, there was 0.47 times lower odds of gingival recession *(Table IV)* and for each 1 mm increase in post-treatment mandibular symphysis width, there was 0.39 times lower odds of gingival recession *(Table V)*.

Predictors specific to upper and lower incisal inclination were evaluated separately. None of the variables were statistically significant to gingival recession (change in U1/SN $P = 0.6$, change in L1/MP $P = 0.5$).

Discussion

Gingival recession following orthodontic treatment has been a debatable topic throughout the years. In this study, 87% of the patients demonstrated gingival recession on at least one of the upper or lower anterior teeth after orthodontic expansion, or extraction that had no association with gingival recession. However, backward selection model showed that treatment with non-extraction case tends to increase the level of gingival recession.

Historically, the position of mandibular incisors has been considered the key for achieving good facial aesthetics [17–21]. A recent systematic review concluded that although there is an association between incisor inclination and gingival recession, the severity of gingival recession cannot be considered clinically significant [11].

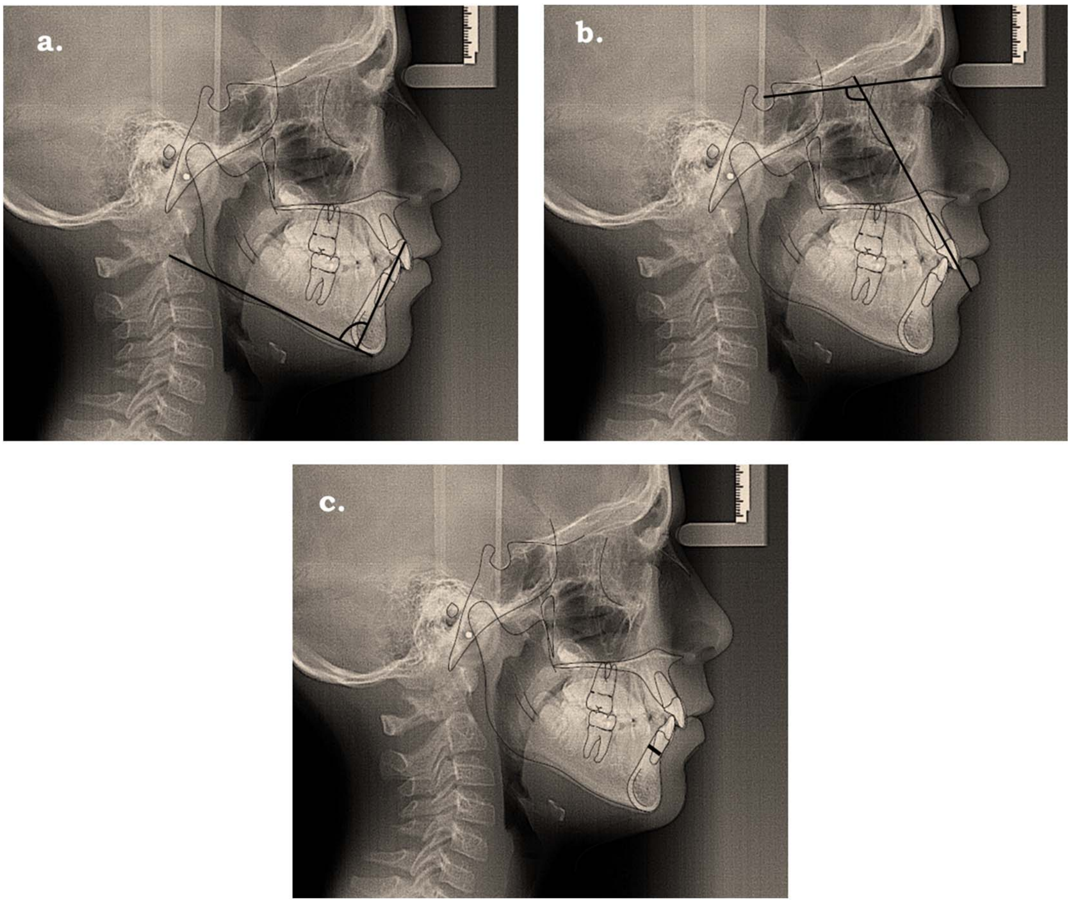

Fig. 4. Cephalogram measurements. (a) Maxillary incisal inclination: angle formed by Sella–Nasion and maxillary incisal planes. (b) Mandibular incisal inclination: angle formed by Menton–Gonion and mandibular incisors planes. (c) Mandibular symphysis width measured as the distance between the anterior border and the posterior border of the symphysis

Table I Means (standard errors) for predictors of gingival recession (by extraction status)

Predictor	Extraction	Gingival recession	Pre-treatment	Post-treatment	Change (post–pre)
Age	No	No	13.77 years (0.10)	N/A	N/A
		Yes	13.72 years (0.12)	N/A	N/A
	Yes	No	14.27 years (0.15)	N/A	N/A
		Yes	14.17 years (0.21)	N/A	N/A
Keratinized gingival height	No	No	3.30 mm (0.05)	3.05 mm (0.05)	−0.26 mm (0.03)
		Yes	2.13 mm (0.07)	1.76 mm (0.06)	−0.37 mm (0.06)
	Yes	No	3.29 mm (0.10)	3.02 mm (0.10)	−0.27 mm (0.08)
		Yes	1.82 mm (0.12)	1.64 mm (0.09)	−0.18 mm (0.08)
Intercanine width	No	No	30.75 mm (0.18)	31.97 mm (0.17)	1.22 mm (0.08)
		Yes	26.78 mm (0.20)	27.98 mm (0.19)	1.20 mm (0.07)
	Yes	No	30.65 mm (0.43)	32.71 mm (0.29)	2.06 mm (0.40)

(Continued)

Table I (Continued)

Predictor	Extraction	Gingival recession	Pre-treatment	Post-treatment	Change (post–pre)
		Yes	26.85 mm (0.36)	28.19 mm (0.34)	1.33 mm (0.24)
Intermolar width	No	No	36.36 mm (0.17)	37.28 mm (0.19)	0.92 mm (0.08)
		Yes	39.12 mm (0.20)	40.34 mm (0.18)	1.22 mm (0.10)
	Yes	No	35.71 mm (0.28)	36.01 mm (0.28)	0.29 mm (0.15)
		Yes	38.82 mm (0.39)	39.07 mm (0.37)	0.25 mm (0.31)
Lower incisors to mandibular plane angle	No	No	90.44° (0.62)	94.17° (0.57)	3.73° (0.38)
		Yes	90.34° (0.40)	94.35° (0.40)	4.01° (0.32)
	Yes	No	91.18° (0.99)	91.46° (0.70)	0.28° (1.00)
		Yes	92.69° (0.97)	93.32° (0.93)	0.63° (0.83)
Mandibular symphysis width	No	No	6.09 mm (0.07)	5.44 mm (0.08)	−0.65 mm (0.05)
		Yes	5.63 mm (0.04)	4.87 mm (0.05)	−0.76 mm (0.03)
	Yes	No	6.58 mm (0.14)	5.67 mm (0.12)	−0.91 mm (0.09)
		Yes	6.22 mm (0.10)	4.99 mm (0.10)	−1.23 mm (0.11)
Arch perimeter	No	No	68.99 mm (0.25)	70.11 mm (0.26)	1.12 mm (0.14)
		Yes	63.85 mm (0.30)	65.08 mm (0.30)	1.23 mm (0.20)
	Yes	No	69.15 mm (0.45)	62.02 mm (0.48)	−7.13 mm (0.45)
		Yes	64.47 mm (0.54)	56.81 mm (0.74)	−7.67 mm (0.73)
Upper incisors to Sella–Nasion plane angle	No	No	100.57° (0.47)	104.82° (0.35)	4.25° (0.39)
		Yes	99.15° (0.70)	103.38° (0.58)	4.23° (0.65)
	Yes	No	104.39° (0.64)	105.40° (0.59)	1.01° (0.84)
		Yes	99.57° (2.24)	105.10° (2.01)	5.53° (3.87)
Spacing crowding	No	No	−1.80 mm (0.15)	N/A	N/A
		Yes	−3.03 mm (0.17)	N/A	N/A
	Yes	No	−5.67 mm (0.38)	N/A	N/A
		Yes	−6.08 mm (0.49)	N/A	N/A
Arch depth	No	No	23.51 mm (0.11)	22.88 mm (0.11)	−0.62 mm (0.07)
		Yes	21.31 mm (0.13)	21.20 mm (0.14)	−0.12 mm (0.10)
	Yes	No	23.47 mm (0.22)	19.53 mm (0.23)	−3.93 mm (0.24)
		Yes	21.35 mm (0.26)	17.42 mm (0.30)	−3.93 mm (0.32)

Table II Best predictors of gingival recession using backward selection

Effect	Estimate	Exponentiated estimate	SE	DF	*t*	*P* value
Intercept	8.68		0.87	99	9.94	<0.0001
Pre-treatment keratinized gingival height	−0.26	0.77	0.10	1,096	−2.60	0.0094
Post-treatment keratinized gingival height	−0.68	0.51	0.13	1,096	−5.05	<0.0001
Post-treatment intercanine width	−0.23	0.80	0.03	1,096	−6.59	<0.0001
Change in arch depth	0.15	1.16	0.06	1,096	2.51	0.0121

$$\begin{aligned} Logit[P(GR=1)] &= 8.68 - 0.26\ (\textit{pre-treatment keratinized ginigval height}) \\ &- 0.68\ (\textit{post-treatment keratinized gingival height}) \\ &- 0.23\ (\textit{post-treatment intercanine width}) \\ &+ 0.15\ (\textit{change in arch depth}) \end{aligned}$$

Table III Best predictors of gingival recession with adding the non-extraction variable

Effect	Estimate	Exponentiated estimate	SE	DF	*t*	*P* value
Intercept	8.49		0.96	98	8.82	<0.0001
Pre-treatment keratinized gingival height	−0.26	0.77	0.10	1,096	−2.61	0.0092
Post-treatment keratinized gingival height	−0.68	0.51	0.13	1,096	−5.06	<0.0001
Post-treatment intercanine depth	−0.23	0.80	0.03	1,096	−6.58	<0.0001
Change in arch depth	0.14	1.15	0.06	1,096	2.13	0.0336
Non-extraction	0.27	1.31	0.51	1,096	0.53	0.5981

$$Logit[P(GR=1)] = 8.49 - 0.26\ (\textit{pre-treatment keratinized ginigval height}) - 0.68\ (\textit{post-treatment keratinized gingival height}) - 0.23\ (\textit{post-treatment inter-canine width}) + 0.14\ (\textit{change in arch depth}) + 0.27\ (\textit{non-extraction treatment})$$

Table IV Pre-treatment mandibular symphysis width as a predictor of gingival recession

Effect	Estimate	Exponentiated estimate	SE	DF	*t*	*P* value
Intercept	5.21		1.31	98	3.97	0.0001
Pre-treatment mandibular symphysis width	−0.75	0.47	0.22	500	−3.46	0.0006

$$Logit[P(GR=1)] = 5.21 - 0.75\ (\textit{pre-treatment mandibular symphysis width})$$

Table V Post-treatment mandibular symphysis width as a predictor of gingival recession.

Effect	Estimate	Exponentiated estimate	SE	DF	*t*	*P* value
Intercept	5.56		1.13	99	4.93	<0.0001
Post-treatment mandibular symphysis width	−0.94	0.39	0.21	499	−4.37	<0.0001

$$Logit[P(GR=1)] = 5.56 - 0.94\ (\textit{post-treatment mandibular symphysis width})$$

Other studies have shown that proclination of mandibular incisors does not result in gingival recession [7, 22, 23]. On the contrary, reclining lower incisors in class III patients tends to increase the risk of gingival recession [24]. In our study, there was no statistically significant relation between incisal inclination and gingival recession. However, anterio-posterior or labial movement of incisors demonstrated by the change in arch depth was found to be statistically significant with gingival recession. There are higher chances for gingival recession in the facial gingiva when anterior teeth are tipped labially.

Mandibular symphysis dimension is an important aspect to be evaluated before incisors movement is planned [25]. Patients with narrow and high symphysis are found to be more susceptible to bone dehiscence and gingival recession [25–27]. This outcome corroborates with the findings of our study where patients have minimum chance of gingival recession with wider pre-treatment and post-treatment symphysis widths. Research indicates that gingival morphology plays an important role in orthodontic treatment decisions [28]. Teeth with keratinized gingival height of ≥2 mm are less susceptible to gingival recession [29]. It was also noteworthy that in this study an increase in the pre- and post-treatment keratinized gingival height was significantly related to a decrease in gingival recession.

Despite the fact that no differences found, various treatment strategies were very close statistical significance ($P = 0.058$). This is probably due to the relatively small sample size of patients which was further divided into three unmatched groups. In addition, the study did not include the assessment of gingival recession on posterior teeth. Furthermore, this study did not assess lingual gingival recession. Statistical analysis was performed for both upper and lower arches as one data pool.

Conclusions

Regardless of any orthodontic treatment modality, increased keratinized gingival height, mandibular symphysis width, and post-treatment intercanine width lower the risk of gingival recession. However, increasing arch depth tends to increase gingival recession. Non-extraction treatment tends to have higher odds of gingival recession.

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Authors' contribution: NS designed the study. NS, AG, KS, and SL wrote the manuscript and revised it prior to submission.

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