Original Article

Cross-sectional evaluation of the prevalence and factors associated with soft tissue scarring after the removal of miniscrews

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ABSTRACT

Objective: To investigate the prevalence of distinguishable soft tissue scarring after the removal of temporary anchorage devices (TADs) such as orthodontic miniscrews and to analyze the factors associated with scar formation.

Materials and Methods: The prevalence of soft tissue scarring in 66 patients (202 miniscrew removal sites) was clinically investigated at least 1 year after miniscrew removal. To determine the clinical factors associated with soft tissue scar formation, miniscrew stability; host factors including age, gender, and gingival biotype; and miniscrew-related factors such as insertion site, vertical position, and insertion period were evaluated.

Results: The prevalence of a distinguishable scar remaining at least 1 year after miniscrew removal was 44.6%. Patients with flat gingiva showed a significantly higher prevalence of soft tissue scar formation than did those with pronounced scalloped gingiva ($P < .05$). Maxillary buccal removal sites showed a significantly higher prevalence of soft tissue scar formation than did those in the mandible or palatal slope ($P < .05$). Miniscrew sites at the alveolar mucosa showed a significantly lower prevalence of soft tissue scar formation than did those in the mucogingival junction or the attached gingiva ($P < .01$).

Conclusion: The prevalence of distinguishable scarring after miniscrew removal was fairly high. On the basis of our results, patients with flat gingiva and buccal interdental gingival insertion sites are more susceptible to scar formation. (*Angle Orthod.* 2015;85:420–426.)

KEY WORDS: Scar; Miniscrew; Wound healing, Removal; Prevalence

INTRODUCTION

Temporary anchorage devices (TADs) such as orthodontic miniscrews are now accepted in contemporary orthodontics as effective orthodontic appliances. During miniscrew insertion, the threads of the miniscrew penetrate the soft tissue, cortical bone, and cancellous bone to provide stability, and the head structure is commonly exposed to the oral cavity. However, unlike dental implants, TADs are by definition temporary devices, which are removed after use. Most clinicians use one simple universal removal scheme, manual turning of the miniscrew in the opposite direction of insertion, assuming that the site will naturally heal over time.

The removal of a miniscrew leaves a transient open wound in the oral cavity that penetrates the soft tissue and the underlying alveolar bone and has a sulcular epithelium component at the wound margin, similar to a tooth-extraction site. Therefore, the healing process after miniscrew removal is assumed to follow the classical healing cascade of an alveolar socket after tooth extraction.[1,2] In clinical dentistry, it is commonly

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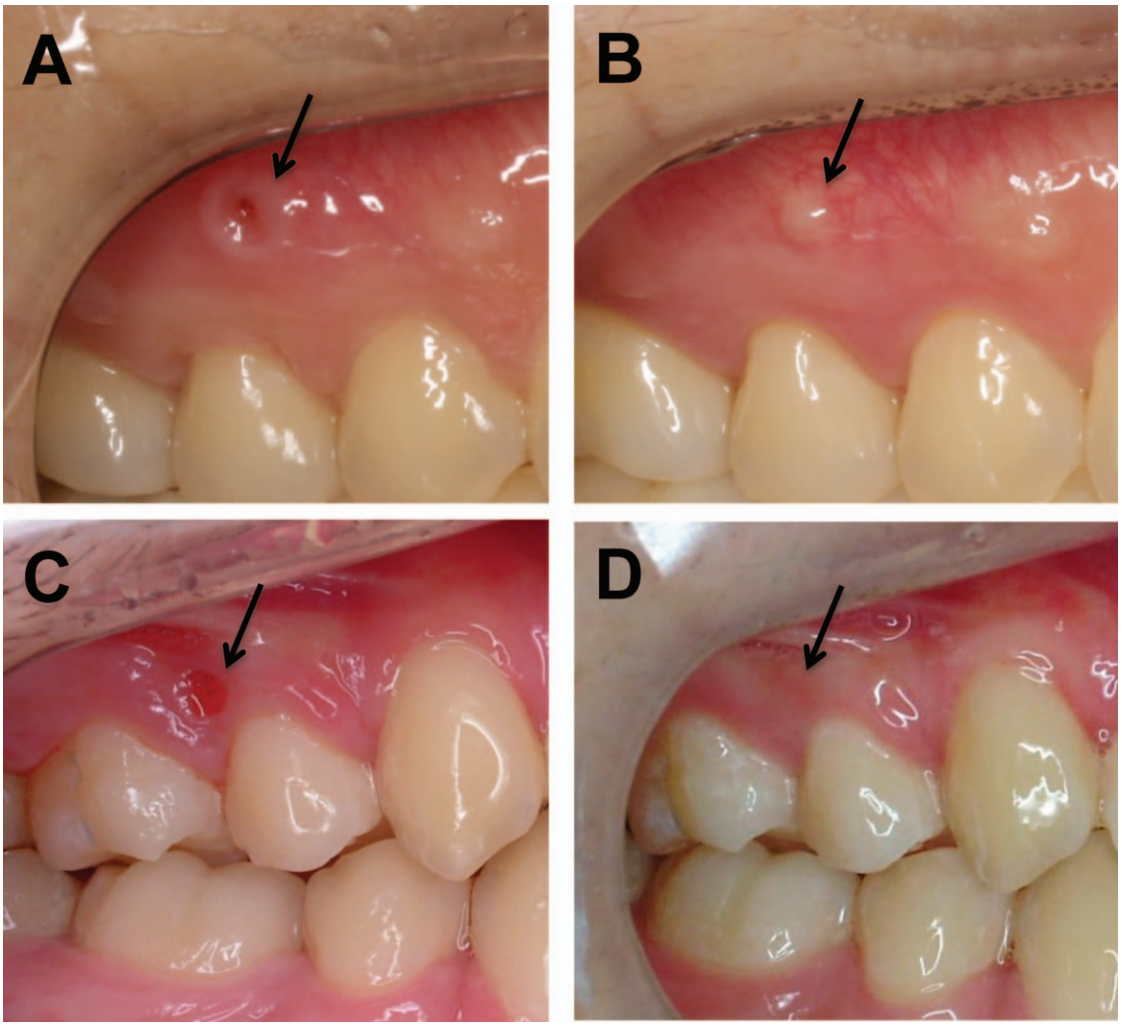

Figure 1. Typical soft tissue scar detected after miniscrew removal. (A, B) Development of a typical soft tissue scar at identical miniscrew removal sites (black arrow) just after debonding and miniscrew removal (A) and 18 months after removal (B). (C, D) Scarless healing of identical miniscrew removal sites (black arrow) just after debonding and miniscrew removal (C) and 12 months after removal (D). Note the presence of distinguishable, whitish, lumplike soft tissue scarring in (B) compared with scarless healing in (D).

accepted that intraoral wounds heal more rapidly with less scar formation than skin wounds,[3–6] and the most favored sites for miniscrew insertion, such as the attached gingiva or the palate, are considered safe zones regarding scar formation.[5,6]

However, clinically distinguishable soft tissue scars are frequently noted after miniscrew removal even years later. In general, the scar tissue is localized to the removal site, has a clear margin and a protuberant appearance similar to a small lump or a wart, and is distinguished from the adjacent tissue by a whitish color (Figure 1A,B). A histological study with Beagle dogs reported that the epithelial lining and inflamed soft tissue surrounding the failed miniscrew due to root touching may not resolve, suggesting the possibility of irreversible soft tissue changes after miniscrew removal.[7] However, the natural course of soft and hard tissue healing, let alone the clinical possibilities of incomplete healing after miniscrew removal, have not been documented in the orthodontic literature.

Therefore, the primary objective of this study was to investigate the overall prevalence of soft tissue scarring after the removal of orthodontic miniscrews. The objectives were (1) participants: adult orthodontic patients (>18 years old); (2) outcome: prevalence of scar formation; and (3) time: 1 year or more after miniscrew removal. In addition, our secondary objective was to retrospectively analyze factors associated with scar formation.

MATERIALS AND METHODS

Subjects

To calculate the overall prevalence of scarring after miniscrew removal, a prospective study was designed. First, an assessment period (July 2012–May 2013)

was set. During the assessment period, all adult subjects (>18 years old) who came in for posttreatment checkups and had used orthodontic miniscrews during treatment at the Department of Orthodontics, Gangnam Severance Hospital, were evaluated for the presence of scarring at miniscrew removal sites.

Wound regeneration including maturation and remodeling usually continues up to 12 months[8,9]; thus, scars detected after 1 year can be considered irreversible. Therefore, subjects examined had completed orthodontic treatment that included the use of miniscrews, and the miniscrews had been removed for at least 1 year (range, 12–58 months) prior to the assessment. Institutional Review Board approval was obtained.

The study cohort consisted of 66 adult subjects: 52 women (mean age, 28.5 ± 10.02 years) and 14 men (mean age, 28.9 ± 8.87 years). Two types of self-drilling miniscrews—the cylindrical type (1.5 mm in diameter, 7 mm in length; ACR OAS-T1507, Biomaterials Korea, Seoul, Korea) or combined cylindrical and tapered type (1.8 mm in diameter, 7 mm in length; Orlus Classic 1O18107, Ortholution, Seoul, Korea)—were used, and all miniscrew heads were exposed to the oral cavity. Orthodontic forces were loaded immediately and directly using elastomeric modules for en masse retraction or molar intrusion. The miniscrews were removed manually using the same hand driver used for insertion. Saline irrigation was performed without any medication after the removal.

Investigation of the Presence of Scar Tissue and Its Prevalence

The examiner clinically assessed the removal sites to determine the presence of scarlike tissue that was distinguishable from the adjacent tissue by its color, morphology, and texture. Scar tissue was defined as present when the removal site showed the following specific features: (1) whitish color distinguishable from the adjacent reddish-pink gingiva or the oral mucosa; (2) small, elevated, lumplike morphology localized to the removal site matching the size of the miniscrew diameter; and (3) firm texture upon palpation compared with the adjacent tissue (Figure 1A,B). Scar tissue was defined as not present when the removal site was indistinguishable from the neighboring tissue (Figure 1C,D). After the clinical evaluation, intraoral photographs were taken. The second examiner reconfirmed the presence of the distinguishable scarlike tissue using intraoral photographs, and interrater reliability was calculated. Of the 66 subjects, 13 had their second visit during the evaluation period (36 sites out of 202 sites). During the second visit, which was in general after 6 months of the primary assessment, the subjects were reexamined by the same examiner, and the intrarater reliability was calculated. The kappa values for the inter- and intrarater reliability were both 1.00, indicating 100% agreement on judging the presence of scars.

Analysis of Factors Associated With Scar Formation

The clinical records of the enrolled subjects were retrospectively collected. Candidate-influencing factors were selected based on previous reports. Miniscrew stability was selected since histological changes were reported following the removal of failed miniscrews, suggesting possibilities of scarring.[7] Host factors such as age and gingival biotypes may influence soft tissue response during healing[10–12]; thus, they were raised as candidate factors. Miniscrew insertion factors such as location were selected because differences in anatomical structures were reported to show differences in healing.[1,3,5]

Miniscrew Stability

Removal sites of clinically stable miniscrews, which showed no sign of mobility and were used successfully until removal, were classified into the success group. Removal sites that had a history of early removal because they were clinically unacceptable for anchorage due to miniscrew mobility were classified into the failure group.[13–16]

Host Factors: Gender, Age, and Gingival Biotypes

Subjects were subdivided into age groups for comparison. Using initial photographs, anatomical crown length (CL; Figure 2, arrow), the distance between the gingival margin and the incisal edge of the crown, and the crown width (CW; Figure 2, dotted arrow), the distance between the approximal tooth surface of the borderline between the portion of the cervical and middle third of the of the maxillary right central incisor were measured, and the crown form ratio (CW/CL) was calculated to determine the pronounced scalloped and flat gingival biotypes as mentioned previously.[10] Of the 66 subjects, the highest and lowest 20% (13 subjects) of each tail in terms of CW/CL ratio were classified into the flat gingival biotype (CW/CL, 0.61 ± 0.097) or the pronounced scalloped gingival biotype (CW/CL, 0.81 ± 0.0759), respectively (Figure 2A,B). In general, the pronounced scalloped gingival biotype is characterized by a long, slender crown form; long interdental papilla; thin buccal marginal gingiva; and narrow attached gingiva, while the flat gingival biotype indicates a relatively short and wide crown form, short interdental papilla,

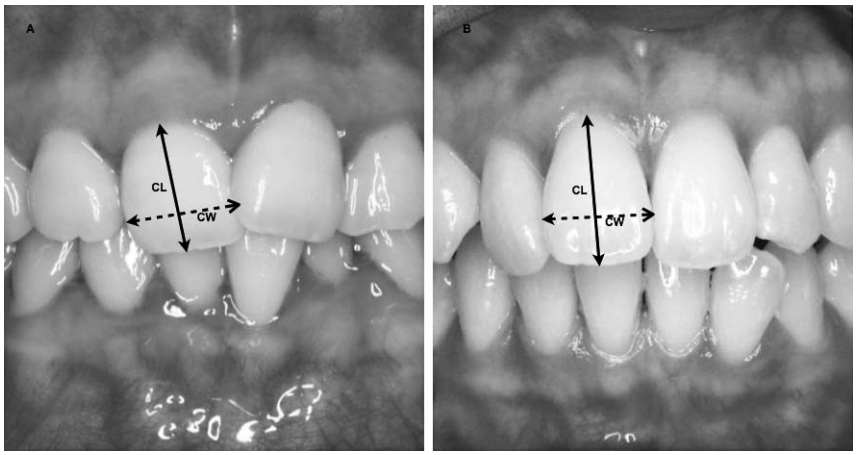

Figure 2. The determination of gingival biotypes. Crown length (CL, arrow), the distance between the gingival margin and the incisal edge of the crown and the crown width (CW, dotted arrow), and the distance between the approximal tooth surface of the borderline between the portion of the cervical and middle third of the of the maxillary right central incisor were measured, and the crown form ratio (CW/CL) was calculated to determine the pronounced scalloped and flat gingival biotypes. Flat gingival biotype (A) indicates a higher anatomical crown width/crown length ratio than pronounced scalloped gingival biotype (B).

thick buccal marginal gingiva, and wide attached gingiva.[10,11,17]

Miniscrew-Related Factors

The buccolingual insertion sites, vertical position, and insertion period were investigated using clinical records including intraoral photographs. The buccolingual insertion sites were divided into the maxillary buccal (including labial), mandibular buccal (including labial), palatal slope, and midpalatal regions. One subject was excluded from the statistical comparison because only one miniscrew was removed from the midpalate. For miniscrews placed in the maxillary or mandibular buccal regions in the vertical position were additionally evaluated and subdivided into three groups: within the attached gingiva, at the mucogingival junction, or within the alveolar mucosa. The palatal slope and midpalatal areas were not classified according to vertical position because these areas are evenly composed of thick, keratinized gingiva. The insertion period was calculated from the date of miniscrew insertion to its removal.

Statistical Analysis

The percentage of distinguishable scars per total sites was calculated. To clarify the relationship between the prevalence of scarring and the clinical factors, the chi-square test was performed and the relative risk was calculated. An independent *t*-test was performed for continuous variables. SAS (Statistical Analysis System, SAS Institute, Cary, NC) software was used for statistical analysis. The significance level was set at $P < .05$.

RESULTS

Prevalence of Distinguishable Scarring After Miniscrew Removal

Of the 66 subjects, 43 had one or more distinguishable scars at the miniscrew removal sites. Of the 202 miniscrew removal sites, 90 presented distinguishable scarring, indicating an overall prevalence of 44.6%.

Of the 202 miniscrews evaluated, 186 were clinically stable until their removal (success group), and the other 16 were removed because they were clinically unacceptable for anchorage due to mobility (failure group). The overall success rate of the 202 miniscrews evaluated was 92.1%. The prevalence of scarring in the success and the failure groups was 45.2% and 37.5%, respectively. The prevalence of scarring was not significantly different between the two groups (Table 1).

Association Between Host Factors and the Prevalence of Scarring

Gender and age. Of the 52 female subjects, 37 had one or more soft tissue scar sites. For men, 6 of 14 had one or more soft tissue scar sites. The prevalence of scarring was 48.2% (81 of 168) for women and 26.5%

Table 1. Prevalance of Scar Formation (%)[a]

	Removal Sites, n	Presence of Scar, n	Incidence, %	*P* Value
Success	186	84	45.2	NS
Failure	16	6	37.5	
Total	202	90	44.6	

[a] NS indicates not significant.

Table 2. Prevalance of Scar Formation According to Gender[a]

Gender	Removal Sites, n	Presence of Scar, n	Incidence, %	*P* Value
Female	168	81	48.2	NS
Male	34	9	26.5	
Total	202	90	44.6	

[a] NS indicates not significant.

(9 of 34) for men. The prevalence of scarring according to gender was not statistically significant (Table 2). Statistical significance was not indicated between the different age groups (Table 3).

Gingival biotypes. In the pronounced scalloped biotypes, 5 of 13 patients had at least one soft tissue scar. In the flat gingival biotypes, 10 of 13 had one or more soft tissue scars. The prevalence of scarring was 18.8% (6 of 32) for pronounced scalloped biotypes and 46.7% (21 of 45) for the flat gingival biotypes. The flat gingival biotypes had a significantly higher prevalence of scarring than did the pronounced scalloped biotypes ($P < .05$; Table 4).

The relative risk of scarring in the flat gingival biotypes was 2.5 (95% confidence interval [CI], 1.13–5.46), indicating a risk of scarring 2.5 times higher than the pronounced scalloped biotypes.

Association Between the Miniscrew-Related Factors and the Prevalence of Scarring

Insertion sites and vertical position. The prevalence of distinguishable scarring in the maxillary buccal, mandibular buccal, and palatal slope regions was 56.6% (69 of 122), 27.4% (17 of 62), and 23.5% (4 of 17), respectively. The maxillary buccal region had a significantly higher prevalence of scarring compared with the mandibular buccal or palatal slope regions ($P < .05$; Table 5). The relative risk of scarring in the maxillary buccal region was 2.1 times that of the mandibular buccal region (95% CI, 1.34–3.18) and 2.4 times that of the palatal region (95% CI, 1.01–5.74).

The prevalence of scarring in the attached gingiva, mucogingival junction, and alveolar mucosa was 58.3% (28 of 48 sites), 50.5% (49 of 97 sites), and 23.1% (9 of 39 sites), respectively. The alveolar mucosa showed a significantly lower prevalence of scarring compared with the attached gingiva or the mucogingival junction ($P < .05$; Table 6). The relative risk of scarring in the attached gingiva was 2.5 (95% CI, 1.36–4.70) and in the mucogingival junction was 2.2 (95% CI, 1.19–4.01), indicating a 2.5 and 2.2 times higher risk of scarring than the alveolar mucosa, respectively.

Table 3. Prevalance of Scar Formation According to Age[a]

Age, Years	10–19	20–29	30–39	≥40	Total	*P* Value
No. of screws	45	91	44	22	202	
No. of scars	16	39	28	7	90	
Incidence, %	35.6	39.8	63.6	31.8	44.6	NS

[a] NS indicates not significant.

Table 4. Prevalance of Scar Formation According to Gingival Biotypes

Gingival Biotype	Pronounced Scalloped Biotype (n = 13)	Flat Biotype (n = 13)	*P* Value
No. of screws	32	45	
No. of scars	6	21	
Incidence, %	18.8	46.7	*

* $P < .05$.

Insertion Period

The mean insertion period of the miniscrews was 11.7 ± 9.13 months in subjects with distinguishable scars and 11. 2 ± 9.03 in subjects without distinguishable scars. The insertion period was not significantly different between the two groups (Table 7).

DISCUSSION

A scar is a fibroproliferative lesion caused by an imbalance between the synthesis and degradation of the extracellular matrix during remodeling after inflammation or trauma.[18] Skin scars with an elevated, firm surface limited to the inflammation or trauma site where the continuity of epithelium was destroyed are classified as hypertrophic scars.[19] The scar remaining after miniscrew removal has similar characteristics as hypertrophic scars of the skin.[20,21] The prevalence of hypertrophic scars in various skin regions is reported to be about 60–63%.[12,22] It is generally accepted that intraoral wounds are less likely to scar than skin wounds.[4,5] Accordingly, we observed that the prevalence of scarring at miniscrew removal sites was 44.6%, lower than skin lesions but not so low as to be ignored.

During the wound-healing process, primary closure of the wound, minimal mechanical stimuli, and sufficient vascularization are essential for favorable healing.[23] In addition, the shallower the wound depth, the better the prognosis for healing.[4,24,25] Because commercially available miniscrews are less than 2 mm in diameter, the current removal schemes do not necessarily recommend primary closure using sutures after miniscrew removal.[26] Even though the regions used for miniscrew insertion (such as the attached gingiva and the palate) are known as the safe zone for scar formation,[4–6] there are several conditions that are unfavorable for scarless healing of miniscrew removal sites regardless of stability. Continuous mechanical stimulation is unavoidable due to mastication and

Table 5. Prevalence of Scar Formation According to Insertion Sites[a]

Insertion Sites	Maxillary Labiobuccal	Mandibular Labiobuccal	Palatal Slope	Midpalatal	Total	*P* Value
No. of screws	122	62	17	1	202	
No. of scars	69	17	4	0	90	
Incidence, %	56.6_a	27.4_b	23.5_b	0	44.6	*

[a] Groups with different subscript letters have a statistically significant difference.
* $P < .05$.

phonation, and the wound penetrates deep into the cancellous bone, which may limit the healing process.

Intrinsic individual characteristics are known to affect the scarring process of wounds.[27] Our results indicate that patients with a flat gingival biotype are more susceptible to scarring than are those with the pronounced scalloped biotype. Individuals with flat gingiva are known to have a lower risk of gingival recession than those with pronounced scalloped gingiva.[10] On the other hand, gingival regrowth is more evident following surgical procedures in the thick flat gingival biotypes compared with the scalloped thin gingival biotypes regardless of age and gender.[11,28] Judging from these findings, patients with flat gingiva may have a more active synthetic process or may be more resistant to degradation. Therefore, during the healing process after miniscrew removal, patients with flat gingiva may synthesize excessive collagen compared with those with pronounced scalloped gingiva, which easily results in hypertrophic scars.

Of the miniscrew-related factors, insertion sites in the alveolar mucosa showed less scar formation than did those in the attached gingiva or the mucogingival junction. Histologically, the alveolar mucosa consists of nonkeratinized epithelium, loose connective tissue with abundant vascularization, and many more elastic fibers than collagen.[11] These histological features might contribute to more favorable wound healing. Maxillary buccal insertion sites are more likely to have detectable scarring compared with those in the mandible. Since the maxillary buccal region has wider attached gingiva compared with the mandible, more miniscrews might have been inserted into the attached gingiva of the maxilla, thereby increasing the risk of scarring. Alternatively, the differences in bone composition between the maxilla and mandible may have caused the significant differences in scarring in these regions. Differences in the presence of food debris, which is reportedly more prevalent in the extraction sockets of the maxilla, may also hinder healing after miniscrew removal.[1]

Clinically, some patients are conscious of the abnormal appearance of the scar tissue and question whether it will disappear over time. Although there is no pain on palpation, esthetic issues may arise when scarring is present in the anterior region. It also creates differences in tactile sensations of the tongue during intraoral functions, especially when located in the palatal region. Most importantly, unexpected and unwanted scarring can reduce patient satisfaction with the treatment outcome.

The gingival biotype may be helpful for predicting the susceptibility to scarring after miniscrew removal, but regulation of intrinsic characteristics is far beyond our treatment scope. On the other hand, regulation of miniscrew-related factors such as insertion sites is more feasible. However, the most favorable and common miniscrew insertion site, the maxillary buccal interdental region within the attached gingival zone,[29–32] turned out to be the most susceptible site for scarring.

Therefore, to solve this clinical dilemma, the development of appropriate postoperative/removal care to promote favorable healing may be necessary. One action may be to provide primary closure of the removal site with sutures or to use pressure garments to inhibit excess proliferation of fibroblasts, protect against irritation, and reduce the scar size as with skin lesions.[20,33,34]

Although miniscrew failure per se did not increase the risk of scarring, our study was cross-sectional, and the course of initial healing was not evaluated. Since infection and persistent inflammation after removal

Table 6. Prevalence of Scar Formation According to Vertical Insertion Position[a]

Vertical Position	Attached Gingiva	Mucogingival Junction	Alveolar Mucosa	Total	*P* Value
No. of screws	48	97	39	184	
No. of scars	28	49	9	86	
Incidence, %	58.3_a	50.5_a	23.1_b	46.7	**

[a] Groups with different subscript letters have a statistically significant difference.
** $P < .01$.

Table 7. Comparison of Insertion Periods Between Subjects With and Without Scarring[a]

	Normal Healing Group (n = 112)	Scar Formation Group (n = 90)	*P* Value
Insertion period, months	11.2 ± 9.13	11.7 ± 9.03	NS

[a] NS indicates not significant.

may cause incomplete healing and result in scarring,[7] the natural course of healing after miniscrew removal and factors influencing initial healing should be further evaluated in the future.

CONCLUSIONS

- The overall prevalence of distinguishable scarring after miniscrew removal was 44.6%.
- The flat gingival biotype and insertion sites in the maxillary buccal interdental region are susceptible for scarring.

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