ORIGINAL ARTICLE

Assessment of Periodontal Parameters Following the Use of Fixed and Removable Space Maintainers in 6–12-year Olds

Zohre Sadat Hosseinipour[1], Kiana Poorzandpoush[2], Alireza Heidari[3], Mojde Ahmadi[4]

Abstract

Aim: Placement of fixed space maintainer (FSM) and removable space maintainer (RSM) may increase the risk of gingivitis in children. This study aimed to assess the effect of using FSMs and RSMs on periodontal parameters in 6–12-year olds.

Materials and methods: This interventional prospective study was conducted on systemically healthy 6–12-year olds (mean age of 8 years) presenting at the Department of Pediatrics, Tehran University requiring space maintainers. The probing pocket depth (PPD), bleeding on probing (BOP), and gingival index (GI) were recorded at the baseline and 6 months after using space maintainers in the abutment teeth in patients with fixed space maintainers and in the tooth with the Adams clasp in children with removable space maintainers as well as the same teeth in the opposing jaw/quadrant as controls.

Results: A significant increase in PPD was noted in distolingual and mesiolingual sites at 6 months after placement of FSM ($p < 0.05$). This increase was not significant for RSM at any site. A significant increase in GI and BOP was also noted at 6 months after placement of FSM and RSM ($p < 0.05$). Caries index did not show a significant change in FSM but caries index significantly increased following the use of RSM.

Conclusion: BOP and GI increase following placement of FSM and RSM, and PPD increases in distolingual and mesiolingual areas of the banded tooth.

Keywords: Dental care for children, Orthodontic, Periodontal index, Space maintenance.

International Journal of Clinical Pediatric Dentistry (2019): 10.5005/jp-journals-10005-1606

Introduction

Bacterial plaque is the most important cause of gingivitis and periodontitis.[1] Plaque growth occurs within a couple of hours and dental plaque must be completely removed at least every 48 hours in periodontally healthy individuals to prevent periodontal disease.

Space maintainers are commonly used in the case of early loss of primary teeth to maintain the space required for the eruption of permanent successors. Fixed space maintainer (FSM) and removable space maintainer (RSM) are routinely used in children. FSMs often include a band, which is placed over the tooth crown and sometimes slightly invades the gingival sulcus. Depending on the type of space maintainer, wires of different shapes may be welded to the band. RSMs include an acrylic body with wires for retention when placed on teeth. These wires sometimes invade the gingival sulcus to provide more retention. These appliances and their band and wires change the contour of the teeth and often result in plaque accumulation. Also, they complicate oral hygiene practice by children. The use of FSMs and RSMs can also cause some periodontal changes due to impaired oral hygiene practice and, further, plaque accumulation following the placement of these appliances, and gingival inflammation may occur.[2] A previous study compared the effects of bands and other orthodontic appliances on the periodontium and showed that bands had a more destructive effect.[3] Alstad and Zachrisson[3] stated that orthodontic treatments may initiate periodontal disease. An increase in probing pocket depth (PPD) has also been reported following orthodontic treatment in patients with poor oral hygiene. However, these pockets can be pseudo-pockets (due to inflammatory conditions) without attachment loss.[1,4] Freitas et al.[5] discussed that treatment with fixed appliances affects the oral microbiota qualitatively and quantitatively. Arikan et al.[6] reported that both FSMs and RSMs may cause gingivitis in children. In a more recent study, the same group of authors discussed that space maintainers should be considered as a source of infection and oral hygiene must be strictly practiced during the use of these appliances.[7]

Despite all the above, no definite consensus has been reached on the effect of orthodontic appliances on dental and gingival health of children. There is a gap of information on the effect of space maintainers used in the mixed dentition period on periodontal parameters. Thus, this study aimed to assess the effect of using FSMs and RSMs on periodontal parameters in 6–12-year olds.

Materials and Methods

This interventional prospective study was conducted on 34 patients, including 21 females and 13 males with a mean age of 8 years who were randomly selected among those presenting to

[1]Department of Pedodontics, Faculty of Dentistry, AJA University of Medical Sciences, Tehran, Iran

[2]Department of Pedodontics, Faculty of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[3,4]Department of Pedodontics, Dentistry School of Tehran University of Medical Sciences, Tehran, Iran

Corresponding Author: Alireza Heidari, Department of Pedodontics, Dentistry School of Tehran University of Medical Sciences, Tehran, Iran, Phone: +98 2188015800, e-mail: zohreshosseinipour@gmail.com

How to cite this article: Hosseinipour ZS, Poorzandpoush K, Heidari A, *et al.* Assessment of Periodontal Parameters Following the Use of Fixed and Removable Space Maintainers in 6–12-year Olds. Int J Clin Pediatr Dent 2019;12(5):405–409.

Source of support: Tehran University of Medical Sciences (TUMS)

Conflict of interest: None

the Department of Pediatrics, Tehran University of Medical Sciences requiring FSM or RSM. The inclusion criteria were (I) cooperative children; (II) no gingival hyperplasia or periodontal disease; (III) no systemic disease; and (IV) no use of drugs causing gingival hyperplasia such as nifedipine. The sample size was calculated to be 34 patients according to a study by Ristic et al.[8]

The study was approved by the Ethics Committee of Tehran University (ethical approval code: 6407). Written informed consent was obtained from the parents or legal guardians of children. Periodontal parameters including GI, PPD, and bleeding on probing (BOP) were measured at the baseline. Also, the abutment teeth for the band and loop in candidates of FSMs and the teeth under the Adams clasp in candidates of RSMs were examined in terms of presence of carious lesions.

Gingival Index

Gingival index (GI) was used to assess the presence/absence and severity of gingivitis. The soft tissue surrounding each tooth was divided into two areas of distal papilla and mesial papilla. The gingival color at these areas was assessed in teeth under the Adams clasp in RSMs and the same teeth in the control jaw and also in teeth under the band and loop in FSMs and the same teeth in the control quadrant.

Pocket Depth

The pocket depth was measured using a Williams probe.

Bleeding on Probing

The periodontal probe was inserted into the distal sulcus (1 mm deep) and gently moved across the sulcus from the facial surface toward the mesial interproximal area; 30 seconds of time were allowed and occurrence of BOP in distal, facial, and mesial surfaces was recorded. The same procedure was repeated in the lingual/palatal surface and BOP in the lingual/palatal surface was also recorded. This index was recorded for teeth under the Adams clasp in RSMs and the same teeth in the opposing jaw and in teeth under band and loop in FSMs and the same teeth in the control quadrant.

Data were analyzed using SPSS version 22 (SPSS Inc., IL, USA), and comparisons were made using the paired *t* test and McNemar's test.

Results

Of patients, 12 required RSMs and 22 required FSMs. Of RSMs, 9 were placed in the mandible and 3 in the maxilla. All FSMs were band and loop placed in the D site and, in all of them, the band was placed on Es, and Cs served as the abutment. Of 22 FSMs, 15 were placed in the maxilla and 7 in the mandible.

Patients with Removable Space Maintainers

Table 1 shows the PPD in distobuccal, midbuccal, and mesiobuccal areas in patients with RSMs at the baseline and at 6 months. According to the paired *t* test, the mean PPD in distobuccal of control teeth in patients with RSM did not change significantly after 6 months compared with the baseline ($p = 1$). This difference was not significant in the test teeth either ($p = 0.58$). The difference in this regard between the test and control teeth was not significant before ($p = 0.58$) or 6 months after the placement of space maintainers ($p = 1$). According to the paired *t* test, the mean PPD in midbuccal of control teeth in patients with RSM did not change significantly after 6 months compared with the baseline ($p = 1$). This difference was not significant in the test teeth either ($p = 0.08$). The difference in this regard between the test and control teeth was not significant before ($p = 0.50$) or after the placement of space maintainers ($p = 0.67$). These differences were not significant for the mesiobuccal area either ($p = 1$. $p = 1$, $p = 0.05$, and $p = 0.16$, respectively).

Table 2 shows PPD in distolingual, midlingual, and mesiolingual areas in patients with RSMs at the baseline and at 6 months in the test and control teeth. None of the afore-mentioned differences were significant in the distolingual area ($p = 0.33$, $p = 1$, $p = 0.43$, and $p = 0.19$), the midlingual area ($p = 0.16$, $p = 1$, $p = 0.72$, and $p = 0.75$), or the mesiolingual area ($p = 1$, $p = 1$, $p = 0.72$, and $p = 0.72$).

Regarding BOP in the test teeth, it was negative in six patients at the baseline and also at 6 months after placement of space maintainers. In five patients, BOP was negative at the baseline and became positive at 6 months after using space maintainers. In one patient, BOP was positive at the baseline and also 6 months after using the space maintainer.

Regarding BOP in the control teeth, BOP was negative at the baseline and after 6 months in 11 patients. BOP was positive in one patient at the baseline and also after 6 months.

In the test teeth, changes in BOP after 6 months compared with the baseline were statistically significant according to McNemar's test and BOP became positive ($p = 0.04$). This change in the control teeth was not significant ($p = 1$). The difference between the test and control teeth was not significant at the baseline in terms of BOP ($p = 1$) but this difference was significant at 6 months ($p = 0.03$).

Table 1: Probing pocket depth in distobuccal, midbuccal, and mesiobuccal areas in patients with removable space maintainers at the baseline and at 6 months in the test and control jaws

Site		*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Distobuccal	Test/baseline	2.0	3.0	2.583	0.4174
	Test/6 months	2.0	3.0	2.583	0.4174
	Control/baseline	2.0	3.5	2.542	0.4981
	Control/6 months	2.0	3.5	2.542	0.4981
Midbuccal	Test/baseline	1.5	2.5	1.917	0.3589
	Test/6 months	1.5	2.5	2.042	0.3965
	Control/baseline	1.0	3.0	2.000	0.4767
	Control/6 months	1.0	3.0	2.000	0.4767
Mesiobuccal	Test/baseline	2.0	3.5	2.750	0.5000
	Test/6 months	2.0	3.5	2.750	0.5000
	Control/baseline	2.0	3.5	2.542	0.4981
	Control/6 months	2.0	3.5	2.583	0.5573

Table 2: Probing pocket depth in distolingual, midlingual, and mesiolingual areas in patients with RSMs at the baseline and at 6 months in the test and control jaws

Site		*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Distolingual	Test/baseline	2.0	3.5	2.583	0.5149
	Test/6 months	2.0	3.5	2.625	0.5276
	Control/baseline	2.0	3.0	2.500	0.4264
	Control/6 months	2.0	3.0	2.500	0.4264
Midlingual	Test/baseline	1.5	2.5	1.917	0.3589
	Test/6 months	1.5	3.0	2.000	0.4264
	Control/baseline	1.5	3.0	1.958	0.3965
	Control/6 months	1.5	3.0	1.958	0.3965
Mesiolingual	Test/baseline	2.0	3.0	2.625	0.3769
	Test/6 months	2.0	3.0	2.625	0.3769
	Control/baseline	2.0	3.5	2.583	0.4687
	Control/6 months	2.0	3.5	2.583	0.4687

Table 3: Probing pocket depth in distobuccal, midbuccal, and mesiobuccal areas in patients with fixed space maintainers at the baseline and at 6 months in the test and control jaws

Site		*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Distobuccal	Test/baseline	1.5	4.0	3.045	0.7056
	Test/6 months	1.0	4.5	3.091	0.9211
	Control/baseline	2.0	4.0	3.205	0.6484
	Control/6 months	2.0	4.0	3.205	0.6484
Midbuccal	Test/baseline	1.0	3.5	2.500	0.6726
	Test/6 months	1.0	4.0	2.636	0.6396
	Control/baseline	1.5	3.5	2.659	0.6246
	Control/6 months	1.5	3.5	2.727	0.5505
Mesiobuccal	Test/baseline	1.0	4.0	2.909	0.7964
	Test/6 months	1.0	4.0	2.636	0.6396
	Control/baseline	2.0	4.0	3.114	0.5759
	Control/6 months	2.0	4.0	3.182	0.5243

In terms of GI in the test teeth, no patient was negative (no inflammation or redness) both at the baseline and after 6 months. In eight patients, GI was negative at baseline but became positive at 6 months. In four patients, GI was positive before and 6 months after using space maintainer. In the test teeth, changes in GI at 6 months compared with the baseline were significant according to McNemar's test and GI became positive ($p = 0.00$).

In terms of GI in the control teeth, GI was negative at the baseline and after 6 months in seven patients. In one patient, GI was negative at the baseline but became positive at 6 months. In four patients, GI was positive at the baseline and at 6 months. The difference in GI at the baseline and at 6 months was not significant in the control teeth ($p = 0.31$).

At the baseline, the difference in GI was not significant between the test and control teeth ($p = 1$) but this difference was significant after 6 months and the frequency of positive GI was significantly higher in the test teeth ($p = 0.00$).

Regarding the presence of caries in patients with RSMs in the test teeth, five patients were caries free at the baseline and at 6 months after receiving space maintainers. In six patients, no carious lesion was noted at the baseline but carious lesions developed in the respective teeth at 6 months. In one patient, carious lesions were present at the baseline and at 6 months. Changes in this regard were significant at 6 months ($p = 0.01$).

In the control teeth, no carious lesions were noted at the baseline and at 6 months in 12 patients. The difference in this regard at the baseline and after 6 months was not significant ($p = 1$). The difference in caries between the test and control teeth was not significant at the baseline ($p = 0.31$). This difference was significant at 6 months and the rate of caries was significantly higher in the test teeth ($p = 0.00$).

Patients with Fixed Space Maintainers

Table 3 shows the PPD in distobuccal, midbuccal, and mesiobuccal areas in patients with FSMs at the baseline and at 6 months. No significant change occurred in PPD at the distobuccal of the abutment teeth ($p = 0.14$) and control teeth ($p = 1$) at 6 months after placement of space maintainers according to the paired *t* test. The difference in PPD of abutment and control teeth at the distobuccal site was not significantly different at the baseline ($p = 0.09$) or at 6 months ($p = 0.75$).

In the midbuccal area of the abutment ($p = 0.90$) or control teeth ($p = 0.08$), no significant change occurred in PPD at 6 months compared to baseline. The difference in PPD of abutment and control teeth at the midbuccal site was not significantly different at the baseline ($p = 0.06$) or at 6 months ($p = 0.24$). The same results were obtained in mesiobuccal as well (all *p*s = 1).

Table 4 shows the PPD in distolingual, midlingual, and mesiolingual areas in patients with FSMs at the baseline and at

Table 4: Probing pocket depth in distolingual, midlingual, and mesiolingual areas in patients with fixed space maintainers at the baseline and at 6 months

Site		*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Distolingual	Test/baseline	2.0	4.5	3.045	0.7385
	Test/6 months	2.0	4.5	3.182	0.7327
	Control/baseline	2.0	4.5	4.159	4.3600
	Control/6 months	2.0	4.5	3.295	0.6298
Midlingual	Test/baseline	1.5	3.5	2.614	0.5549
	Test/6 months	2.0	4.0	2.705	0.5908
	Control/baseline	1.5	3.5	2.659	0.6246
	Control/6 months	1.5	3.5	2.727	0.5505
Mesiolingual	Test/baseline	2.0	4.0	3.023	0.6264
	Test/6 months	2.0	4.0	3.227	0.6497
	Control/baseline	1.5	4.5	3.182	0.6463
	Control/6 months	2.5	4.5	3.250	0.5510

6 months. In the distolingual area of abutment teeth, a significant change occurred in PPD at 6 months compared to the baseline and PPD significantly increased ($p = 0.03$). The change in PPD at the distolingual site of the control teeth was not significant ($p = 1$). A significant difference was noted in PPD between abutment and control teeth at the baseline and PPD was significantly greater in abutment teeth ($p = 0.02$). But this difference was not significant at 6 months ($p = 0.16$).

In the midlingual site of abutment and control teeth, PPD did not change after 6 months (both *p*s = 1). The difference in PPD between abutment and control teeth was not significant at the baseline or after 6 months (both *p*s = 1).

In the mesiolingual site of abutment teeth, the change in PPD was significant at 6 months and PPD increased ($p = 0.03$). This change was not significant in the control teeth ($p = 0.03$). The difference between abutment and control teeth at the baseline was significant and the abutment teeth showed significantly higher PPD at the baseline ($p = 0.03$). This difference was not significant at 6 months ($p = 0.78$).

In terms of BOP in abutment teeth, in 15 patients, BOP was negative before and 6 months after receiving the space maintainers. In seven patients, BOP was negative at the baseline but became positive after 6 months.

In terms of BOP in the control teeth, BOP was negative before and 6 months after receiving space maintainers in 19 patients. In one patient, BOP was negative but became positive after 6 months. In two patients, BOP was positive and became negative 6 months after.

In abutment teeth, changes in BOP at 6 months after receiving space maintainer were significant and BOP became positive ($p = 0.01$). In the control teeth, this change was not significant ($p = 1$). At the baseline, the difference between abutment and control teeth was not significant ($p = 0.50$). At 6 months, the difference in BOP between abutment and control teeth was significant and BOP became positive in abutment teeth ($p = 0.03$).

In terms of GI in abutment teeth, GI was negative in nine patients before and 6 months after receiving the space maintainer. GI was negative at the baseline and became positive at 6 months in eight patients. In five patients, GI was positive at the baseline and at 6 months.

In terms of GI in the control teeth, GI was negative at the baseline and at 6 months in 16 patients. GI was negative at the baseline but became positive at 6 months in one patient. In four patients, GI was positive at the baseline and after 6 months. In one patient, GI was positive at the baseline but became negative after 6 months.

Changes in GI in the abutment teeth were significant at 6 months compared with baseline and GI became positive ($p = 0.00$). In the control teeth, this change was not significant ($p = 1$). The difference in GI between the abutment and control teeth was not significant at the baseline but became significant at 6 months and BOP became positive in abutment teeth ($p = 0.00$).

In terms of caries in abutment teeth, 18 patients were caries free at the baseline and after 6 months. Four patients were caries free at the baseline but developed caries at 6 months. In terms of caries in control teeth, 18 patients were caries free at the baseline and after 6 months. Two patients were caries free at the baseline and developed caries at 6 months. Two patients had caries at the baseline but carious teeth were restored at 6 months. In abutment teeth, changes in caries were not significant at 6 months ($p = 0.12$). In control teeth, this change was not significant either ($p = 1$). The difference in this regard between the abutment and control teeth was not significant at the baseline ($p = 0.50$) or at 6 months ($p = 0.62$).

Discussion

This study assessed periodontal parameters and caries at the baseline and 6 months after placement of space maintainers. Also, the opposing jaw in patients with RSMs and the other quadrant in patients with FSMs served as control. The PPD in patients with FSMs did not change significantly at 6 months in mesiobuccal, midbuccal, distobuccal, and midlingual areas but the PPD significantly increased at 6 months in mesiolingual and distolingual areas of abutment teeth. Bands have a sharp edge and can penetrate deeper into the gingival sulcus than Adams clasp in RSMs. On the contrary in the distal of Es, gingiva extends above the cementoenamel junction (especially during eruption of permanent first molars). Thus, this area is more susceptible to injury due to band placement. In the mesial and distal areas, the gingiva is positioned more coronally due to the presence of papillae. Thus, the gingiva is more susceptible to traumatization during band placement. Moreover, oral hygiene maintenance is more difficult in the lingual surface due to difficult access. In abutment teeth, the loop compresses the distal gingiva. Also, food impaction beneath the loop can cause periodontal problems in this region.

Our results regarding the PPD in the use of FSMs were in agreement with those of Huser et al.,[9] who assessed clinical and microbiological effects of orthodontic bands and found no significant difference between the case and control groups in PPD; but our results were in contrast to the results of Arikan et al.[6] The absence of a significant difference in PPD in the use of RSMs at the baseline and at 6 months may be attributed to the position of the Adams clasp on tooth because the borders of the Adams clasp only enter into the free gingiva and are not sharp (in contrast to the borders of FSPs); the only drawback of RSMs is food impaction.

Comparison of GI at the baseline and at 6 months after placement of space maintainers showed a significant difference in both FSM and RSMs and both space maintainers caused an increase in GI and a dark red discoloration in the gingiva. The reason is poor oral hygiene in most of our patients. Although dental cleaning and prophylaxis was performed for all patients before the study, they still had poor oral hygiene and placement of space maintainer further complicated oral hygiene practice. Moreover, space maintainers change the tooth contour and enhance plaque accumulation, which leads to gingivitis. Our results regarding changes in GI were in line with those of Arikan et al.,[6,7] Thilagrani et al.,[10] Zachrisson,[11] and Dubey et al.[12] Changes in BOP were also significant 6 months after using both types of space maintainers except for the abutment tooth in band and loop space maintainers, in which this difference was not significant. Tooth contour changes after banding, which complicates oral hygiene practice. But no change occurs in the contour of anchor tooth and free gingiva remains intact; this explains no significant difference in BOP of anchor tooth. Our results regarding the significant change in BOP after using FSM and RSM were in agreement with those of Arikan et al.,[6] on periodontal status of children with space maintainers, Thilagrani et al.,[10] Zachrisson,[11] and Dubey et al.[12]

Comparison of caries index at the baseline and 6 months after placement of space maintainers showed that the change was significant in the use of RSMs but insignificant in the use of FSMs. The possible reason is higher food impaction in the use of RSMs, because RSMs are larger in size than FSMs and further complicate oral hygiene practice. However, in the use of band and loop, oral hygiene practice in the occlusal surface is the same as that in the control side. Our results in this respect were in accord with those of Toodezaeim et al.,[13] on the colonization of *Streptococcus mutans* and Chen and Zhou[14] on the prevalence of caries in patients with fixed appliances since they found no significant change in DMFT of these patients.

Future studies with larger sample size and longer follow-ups are required to assess the reversibility of increase in GI, BOP, and PPD after removal of space maintainers.

Conclusion

The results of this study showed that the use of FSMs had no significant effect on the development of caries in abutment teeth but changed GI and BOP in these teeth. Also, FSMs increased PPD in the distolingual area of these teeth. The use of RSMs caused caries and increased GI and BOP in the respective arch but had no effect on PPD.

References

1. Lovegrove JM. Dental plaque revisited: bacteria associated with periodontal disease. J N Z Soc Periodontol 2004(87):7–21.
2. Goenka P, Sarawgi A, et al. Simple fixed functional space maintainer. Int J Clin Pediatr Dent 2014 Sep-Dec;7(3):225–228. DOI: 10.5005/jp-journals-10005-1272.
3. Alstad S, Zachrisson BU. Longitudinal study of periodontal condition associated with orthodontic treatment in adolescents. Am J Orthod 1979 Sep;76(3):277–86. DOI: 10.1016/0002-9416(79)90024-1.
4. Srivastava B, Chandra S, et al. Cross-sectional study to evaluate variations in attached gingival and gingival sulcus in the three period of dentition. J Clin Pediatr Dent 1990 Fall;15(1):17–24.
5. Freitas AO, Marquezan M, et al. The influence of orthodontic fixed appliances on the oral microbiota: a systematic review. Dental Press J Orthod 2014 Mar-Apr;19(2):46–55. DOI: 10.1590/2176-9451.19.2.046-055.oar.
6. Arikan F, Eronat N, et al. Periodontal conditions associated with space maintainers following two different dental health education techniques. J Clin Pediatr Dent 2007 Jul;31(4):229–234. DOI: 10.17796/jcpd.31.4.9588m43n027t560n.
7. Arikan V, Kizilci E, et al. Effects of fixed and removable space maintainers on plaque accumulation, periodontal health, candidal and *Enterococcus faecalis* carriage. Med Princ Pract 2015 Jun 4;24(4):311–317. DOI: 10.1159/000430787.
8. Ristic M, Svabic MV, et al. Clinical and microbiological effects of fixed orthodontic appliances on periodontal tissues in adolescents. Orthod Craniofac Res 2007 Nov;10(4):187–195.
9. Huser MC, Baehni PC, et al. Effects of orthodontic bands on microbiologic and clinical parameters. Am J Orthod Dentofacial Orthop 1990 Mar;97(3):213–218. DOI: 10.1016/S0889-5406(05)80054-X.
10. Thilagrani PR, Agarwal AP, et al. Association of Periodontal Health with Orthodontic Appliances among Indian Patients. J Int Oral Health 2015 Jan;7(1):44.
11. Zachrisson BU. Cause and prevention of injuries to teeth and supporting structures during orthodontic treatment. Am J Orthod 1976 Mar 1;69(3):285–300. DOI: 10.1016/0002-9416(76)90077-4.
12. Dubey R, Jalili VP, et al. Oral hygiene and gingival status in orthodontic patients. J Pierre Fauchard Acad 1993 Jun;7(2):43–54.
13. Toodezaeim MH, Zandi H, et al. Investigating and comparing the colonization of mutans streptococus in different parts of removable orthodontic appliances. J Shahid Sadoughi Univ Med Sci 2013;21(3 Suppl):406–414.
14. Chen W, Zhou Y. Caries outcomes after orthodontic treatment with fixed appliances: a longitudinal prospective study. Int J Clin Exp Med 2015;8(2):2815.