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# Plaque deposition around conventional and self-ligating brackets in patients undergoing orthodontic treatment

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## ABSTRACT

*Aim:* The purpose of this study was to compare and evaluate the accumulation of plaque around brackets, colonization of *S. mutans* and other microorganisms on brackets that self-ligated or ligated with elastomeric ligation in fixed appliance. Patients' self-esteem improves as a result of enhanced esthetics and a more appealing smile provided by orthodontic therapy. On the other hand the tour of orthodontic treatment raised the risk of teeth decalcification as a result of plaque accumulation near the brackets, which can result in white spot lesions. *Materials and Methods:* Three hundred twenty orthodontic patients from males and females aged from (15-45 years old) were prepared for fixed orthodontic treatment. Self-ligation orthodontic brackets (Damon) and conventional type brackets (Dantaurum) were used. Filtek 4gr 3M composite material was used; all patients used the same type of adhesive (3M Unitek). The accumulation of microbial and periodontal plaque was recorded twice: T1 after three months and T2 after six months. Microbiological examinations of the oral microbiota were used to provide a quantitative analysis for *streptococcus mutans*, *Staphylococcus aureus*, *Streptococcus mitis* and *Streptococcus oralis*. *Results:* When comparing the conventional with self-ligating brackets, The results showed that accumulation of *S. mutans* in conventional ligature was 4.9 times higher than Self-ligating, colony forming units ($P<0.05$). *Conclusion:* Self-ligating brackets appliance system showed superior plaque control and reduced bacterial colonization as compared with conventional ligation approach.

**Keywords:** plaque control, biofilm retention, randomized clinical study, self-ligation, *Streptococcus mutans*.

## 1. INTRODUCTION

Caries and periodontal disease are two significant and highly prevalent infectious diseases that are caused by this microbiota's complex and dynamic microbial community (Vaid et al., 2014; Purmal et al., 2010). The oral

microbiota in the human mouth has a variety of habitats and at least 400 to 700 distinct bacteria kinds, in the orthodontic field, the main issues of interest are enamel demineralization and cavities (Baka et al., 2013; Jung et al., 2014; Nassar et al., 2021). Caries in teeth is attributable to Bacterial carbohydrate metabolism and the action of acid products, especially *Streptococcus mutans, Staphylococcus aureus, Streptococcus mitis* and *Streptococcus oralis* (Iwano et al., 2010; Takahashi & Nyvad, 2011; Almabadi et al., 2020). Following the bonding of orthodontic appliances, these species proliferate after 6 to 12 weeks (Sanpei et al., 2010). In recent years, self-ligating brackets have become increasingly common. Self-ligation, on the other hand, is not a brand-new idea, Stolzenberg (1935) invented the initial and primary (self-ligating bracket, the Russell-attachment, in the early 1930s). Since It did not achieve much popularity at the time, may be because to a lack of promotion or skepticism among the orthodontic society. With the development of several sorts of modern self-ligating systems in course of the last few decades, there has been a resurgence of interest in self-ligating brackets. Many benefits have been offered for these self-ligating brackets over traditional edgewise brackets.

Brackets that self-ligate are thought to possess ability to produce more physiologically harmonious tooth movement because of neither overriding the muscle nordisrupting the vascular supply of the periodontal tissues (Damon, 1998). As a result, there is more alveolar bone production, more expansion, less anterior tooth proclination, and there are fewer extractions. More alleged benefits are complete wire ligation (Harradine, 2003), improved mechanics of sliding, as well as the possibility of anchorage preservation (Damon, 1998; Berger, 2008). Treatment times are shorter, treatment intervals are longer, and appointments are fewer (Damon, 1998; Eberting et al., 2001; Harradine, 2001), saving time in the chair, reducing the need for chair-side assistance, and improving ergonomics as well as better oral hygiene (Paduano et al., 2008). Infection control is improved, and patients are more comfortable (Damon, 1998; Berger, 2008).

In the laboratory, many experiments have proven that self-ligating brackets cause less friction than conventional brackets (Griffiths et al., 2005; Henao & Kusy, 2005; Khambay et al., 2004; Kim et al., 2008). Brackets that self-ligate have some drawbacks, including a higher price, there's a chance that the clip or slide will break, Owing to the mechanical design, there is a larger risk of occlusal interferences and lip discomfort, as well as trouble finishing due to incomplete arch wire expression. The Damon group had 4-month shorter treatment period and needed an average of four fewer visits. Opening, closing of the slides was much faster than with traditional ligation. Occlusal irregularity was reduced equally well with both types of brackets (Pandis et al., 2006). Where as when comparing the two groups, there was no noticeable difference between the two groups (Hamilton et al., 2007).

Our research, a clinical randomized trial to figure out the effect of two distinct ligation systems on the colonization of *S. mutans* and accumulation of bacterial plaques, was comparing the clinical parameters of periodontal, microbiological environment by using an experiment on plaque growth for 3 months (T1), 6 months (T2), respectively.

## 2. MATERIALS AND METHODS

Patients were chosen at random from the Department of Pediatric Dentistry and Orthodontics of RUDN University in Moscow, Russia, who were scheduled to begin orthodontic treatment with mandibular and maxillary fixed appliances. The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation. This study was approved by the medical ethics committee of RUDN University (Protocol number 30/17.06.21) and patients or their parents supplied written informed permission. We have divided our patients into two teams: each team consist of 4 groups, the teams differ by gender, age, and type of brackets. Each group consists of 40 patients, we divided the patients according to the type of orthodontic brackets into two categories, the first four groups used self-ligating brackets, and the second four groups used conventional brackets. At various points throughout the study, we assessed the clinical index evaluations, the samples of supragingival plaque from these participants.

*Inclusion criteria:* Moderate to minimal crowding, permanent dentition, no extraction, fixed orthodontic therapy, appropriate oral hygiene, with the right-hand brushing, while Impacted or missing teeth (excluding molars), and antibiotic usage within the previous three months, systemic disease, were all factors for exclusion.

Following the initial assessment, scaling, and polishing of the supragingival area was performed on all patients, as well as oral hygiene advice was given. It was recommended that they wash their teeth two times every day, and they were given toothpaste and toothbrushes that are all in uniform, they told not to use any other dental care products for all duration of the study. They were also told to keep their normal eating patterns. The Appointments for patients were made for sampling; bonding processes three weeks following their initial assessments. Two groups of patients were formed at random:

- In first team Bonding was done with self-ligating brackets (Ormco, Damon Q) n=40. Second team Bonding was done with traditional brackets (Roth-equilibrium, Dentaurum) n=40 and both with 0.022-in slots.

- Ligature with elastomeric ligation were used to ligate the traditional brackets. The initial leveling was done with a 0.014-in copper-nickel titanium arch wire. Three months after bonding, 6 months after brackets bonding, clinical periodontal parameters such as (bleeding on probing, probing pocket depth, plaque index) were taken. The researcher used (Hu-Friedy, Chicago, Ill) periodontal probe to perform the periodontal examination.

The sampling was done in the morning, and patients requested not to try eating or cleaning their teeth at the days of their appointments. The sampling taking from tooth by using sterile hiculture transport swab and stored at 20°C preparing for examination of the oral micro flora (figure 1 & 2). Colony forming unit/ml was calculated by dividing numbers of colonies counted on plate on volume of sample multiplying by dilution. For example if we had 240 colony and the volume of sample was 1ml and dilution equal to $10^{-2}$, this means that cfu/ml = 24000 colony/ml of sample. The duration of the study is nearly 8 months from May 2021 to December 2021.

**Figure 1** Plaque swab collection on teeth ligated with elastomeric ligatures (conventional ligation)

**Figure 2** Plaque swab collection tool

## 3. RESULT

After 6 months of bonding, the average values of bacterial numbers, clinical periodontal measures found to be different and statistically significant between two groups and within each group. Bearing in mind, that the greatest value was notice in the side of conventional type brackets (Table 1). Display descriptive information about two groups and comparative values of bacterial

numbers within the period of T1 and T2. The numbers of *Streptococcus mutans, Staphylococcus aureus, Streptococcus mitis* and *Streptococcus oral* is increased significantly after the orthodontic brackets were bonded (P <0.05). But we found that the team that ligated with conventional type brackets had more plaque accumulating and bacterial colonization than team that was ligated with self-ligating brackets. We see that after 6 months of orthodontic treatment T2, the rate of microorganisms, periodontal parameters increased. Table 2 showed comparison in bacterial numbers between self-ligating group and conventional group, both groups have noticeable increase in bacteria and the difference was statistically significant (P <0.05). We noticed through means values that self-ligating brackets had less bacterial colonization than conventional Brackets and *S. mutans* had the highest mean values.

**Table 1** Comparisons between groups according to bacterial counts, standard Deviations, Means (Log CFU/mL), M.N = MEANS, S.D = standard deviations

| | | T1 | | T2 | | |
|---|---|---|---|---|---|---|
| | GROUP No 40 | M.N | S.D | M.N | S.D | T2-T1 |
| *S.mutans* | Self-ligating | 2.36 | 0.74 | 3.09 | 0.84 | 0.73 |
| | Con.ligature | 6.15 | 0.67 | 9.74 | 1.11 | 3.59 |
| *S.aureus* | Self-ligating | 1.79 | 0.83 | 3.34 | 1.53 | 1.55 |
| | Con.ligature | 4.36 | 2.45 | 8.09 | 1.23 | 3.73 |
| *S.mitis* | Self-ligating | 2.1 | 0.33 | 4.23 | 1 | 2.13 |
| | Con.ligature | 5.39 | 2.82 | 9.21 | 1.67 | 3.82 |
| *S.oralis* | Self-ligating | 2.82 | 0.83 | 4.45 | 1.03 | 1.63 |
| | Con.ligature | 4.45 | 0.36 | 9.05 | 1.21 | 4.6 |

**Table 2** Intergroup comparison according to bacterial counts (log CFU/ML)

| | | Self-ligating | | | | Conventional ligature | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Minimum | Maximum | Mean | SD | Minimum | Maximum | P value |
| S.mutans | 40 | 2.725 | 0.57 | 0.04 | 4.51 | 7.945 | 0.66 | 0.05 | 13.19 | 0.01 |
| S.aureus | 40 | 2.565 | 0.37 | 0.17 | 4.32 | 6.225 | 1.47 | 0.06 | 8.98 | 0.02 |
| S.mitis | 40 | 3.165 | 1.54 | 0.09 | 5.12 | 7.3 | 1.27 | 0.15 | 11.73 | 0.04 |
| S.oralis | 40 | 3.635 | 1.14 | 0.16 | 5.26 | 6.75 | 2.01 | 0.17 | 11.78 | 0.04 |

Table 3 showed described data for distinction of periodontal measures for each groups. The initial (pockets depth, bleeding in time of probing, and plaque index) volumes within each groups increased statistically and significantly after the orthodontic brackets were bonded, and that increases maintained throughout the research (P <0.05). With the respect, that group ligated with conventional brackets had more plaque accumulation than the group ligated with self-ligating brackets. Periodontal parameters increased after 6 months of brackets bonding and conventional Brackets had the greatest values.

**Table 3** comparisons between groups according to periodontal measurements, standard Deviations, Means

| | | T1 | | T2 | | |
|---|---|---|---|---|---|---|
| | Group | Mean | SD | Mean | SD | T2-T1 |
| (Plaque index) | Self-ligating | 1.13 | 0.35 | 2.17 | 0.11 | 1.04 |
| | Con.ligature | 6.11 | 0.75 | 9.48 | 0.34 | 3.37 |
| (Bleeding on probing) | Self-ligating | 42.17 | 11.31 | 60.83 | 8.3 | 18.66 |
| | Con.ligature | 81.83 | 19.37 | 93 | 9.05 | 11.17 |
| (Probing pocket depth) | Self-ligating | 3 | 0.23 | 5.53 | 0.49 | 2.53 |
| | Con.ligature | 7.02 | 1.37 | 10.71 | 0.26 | 3.69 |

Table 4 presents a comparison ofperiodontal measures across groups. Both groups showed increases at bleeding in time of probing, pockets depth, plaque index, this differences is statistically significant (P <0.05). Between groups, there were measureable and statistically high increases when we examined the overall periodontal or microbiologic effects by multivariate analysis of variance (P <0.05). In addition, the conventional group showed more periodontal changes than the self-ligated group. We noticed that after 6 months of orthodontics treatment that periodontal parameters increased and the results values of self-ligating less than conventional ligature. This means that self-ligating brackets more hygienic than conventional brackets. Plaque index, bleeding on probinghad a substantial positive connection; the other associations were found to be insignificant statistically.

The results (figure 3 and 4) showed that accumulation of *S. mutans* in conventional ligature was 4.9 times higher than Self-ligating, and the S. *aureus* numbers was 2.4 times in conventional ligature higher than Self-ligating while in *S. mitis* the accumulation showed that conventional ligature higher than Self-ligating in 1.7 times, and *S. oralis* showed that conventional ligature higher than Self-ligating in 2.8 times. Plaque index in conventional ligature increased 3.2 times when comparing with Self-ligating after 6 months, while bleeding on probing increased 1.6 times in conventional ligature. Probing pocket depth increased 1.4 times in conventional ligature.

**Table 4** intergroup comparison according to periodontal measurements, standard Deviations, Means

| | Self-ligating | | | | Conventional ligature | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Minimum | Maximum | Mean | SD | Minimum | Maximum | P value |
| (Plaque index) | 1.65 | 0.38 | 0.33 | 3.03 | 7.795 | 1.34 | 0.26 | 11.96 | 0.04971 |
| | | | | | | | | | |
| (Bleeding on probing) | 51.5 | 16.87 | 0.01 | 77 | 87.415 | 15.53 | 10.33 | 97.33 | 0.03892 |
| | | | | | | | | | |
| (pocket depth) | 4.265 | 0.21 | 0.06 | 7.23 | 8.865 | 1.32 | 0.01 | 12.2 | 0.02692 |
| | | | | | | | | | |

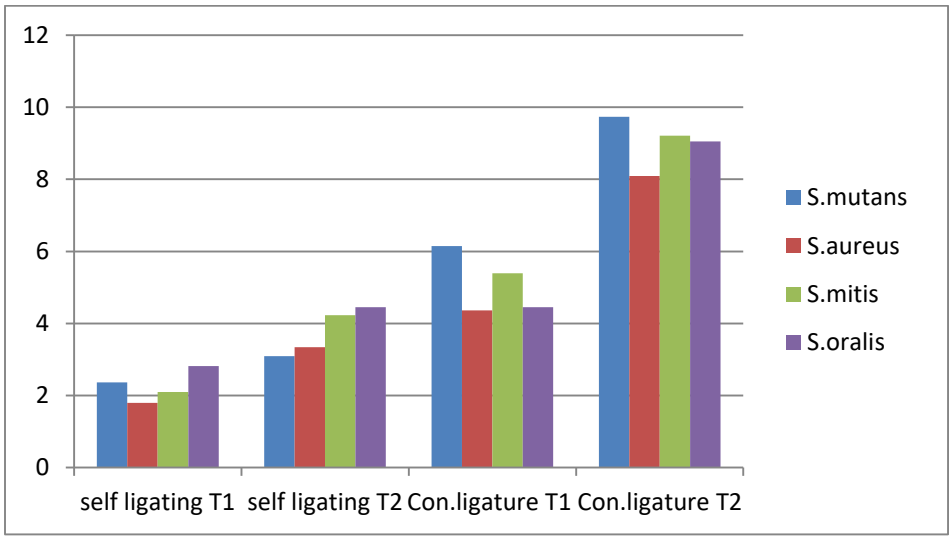


**Figure 3** comparisons according to bacterial counts

**Statistical analysis**

The data was statistically analyzed using SPSS version 20. The Mann Whitney U test was used to assess differences between the groups in terms of microbiologic and periodontal data. The results were considered to be statistically significant at $p \leq 0.05$. The clinical and microbiologic parameters were correlated using the Pearson correlation test.

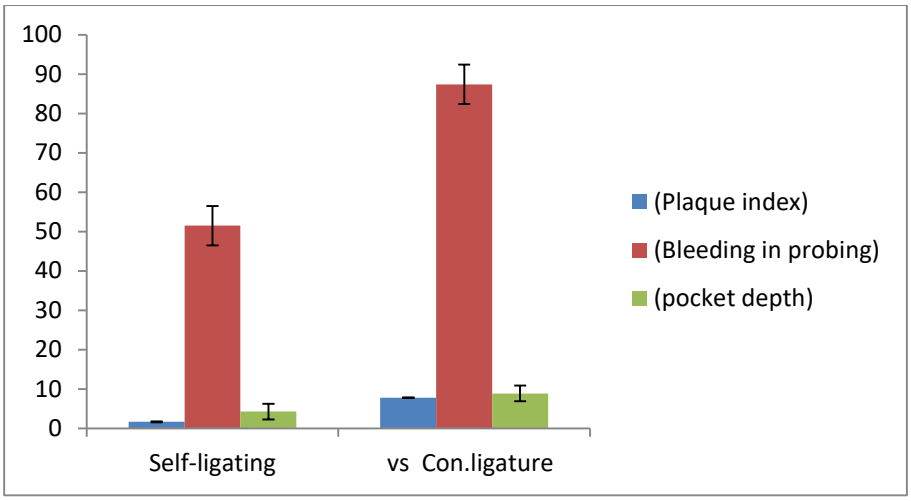


**Figure 4** Comparision according to periodontal measurements

## 4. DISCUSSION

Many researches have looked at the impact of fixed orthodontic mechanotherapy on plaque biofilm development and bacterial colonization (Balenseifen & Madonia, 1970; Corbett et al., 1981; Rosenbloom & Tinanoff, 1991; Peros et al., 2011; Liuet al., 2011). Several researches, on the other hand, have looked at plaque bacteria adherence using various ligature methods (Pellegrini et al., 2009; Garcez et al., 2011; Forsberg et al., 1991; Türkkahraman et al., 2005; Alves de Souza et al., 2008). Plaque development differs from patient to patient due to a variety of factors including oral hygiene, nutrition, age, systemic disorders, and other factors, as well as dental malocclusion, which causes plaque retention to increase. Previous research comparing the impact of Self-ligating brackets against conventional type on periodontal health and when they used elastomeric ligature as the ligation method, they found that elastomeric ligatures have been established to be a bio-hostile material (Pellegrini et al., 2009; Forsberg et al., 1991; Alves de Souza et al., 2008; Gameiro et al., 2009).

The findings of our investigation are supported by Forsberg et al., (1991) and Pellegrini et al., (2009). While Tukkahraman et al., (2005) showed there were no significant variations in the numbers of microorganisms identified from teeth ligated with either elastomeric rings or steel ligature wires. Garcez et al., (2011) found that the amount and composition of biofilm near different types of brackets differed significantly, in in-vitro circumstances; they found that traditional brackets ligated with stainless steel ligature had less supra-gingival biofilm than self-ligating brackets Gastel et al., (2007) have also shown that the bracket designs can have a considerable impact on bacterial load and periodontal parameters.

## 5. CONCLUSION

*Streptococcus mutans*, *Staphylococcus aureus*, *Streptococcus mitis*, and *Streptococcus oralis* colonization is highly increased by fixed orthodontic appliances, the prevalence of *S mutans* was larger than that of the other microorganisms. During the first three months of orthodontic treatment, the plaque index, bleeding in time of probing, and pocket depth values all increased significantly. When comparing the self-ligating brackets system with the conventional ligation using an elastomeric module, this study found that the conventional ligation produced more plaque.

**Author Contributions**

Mustafa azhar Al-okbi: Conceptualization, Methodology, Data curation, Writing- Original draft preparation.
Tamara Kosyreva: Conceptualization, Investigation, Methodology, Supervision.
Imad Katbeh, Nikolay Tuturov: Data curation, Writing- Original draft preparation, Writing - review & editing.
Olga Voeykova, Alexey Birukov: Writing - original draft; Writing - review & editing.

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**Conflict of interests**

The authors declare that there are no conflicts of interests.

**Data and materials availability**

All data associated with this study are present in the paper.

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