Original Article

# Evaluation and Comparison of the Effect of Elastomeric Chain and Stainless Steel Ligature Wire on Maxillary Orthodontic Miniscrew Failure

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## Abstract

**Context:** Orthodontic miniscrews are used for the purpose of conservation of anchorage. **Aims:** The aim of the study was to evaluate the orthodontic miniscrew failure between the elastomeric chain-supported retraction and stainless steel (SS) ligature-aided retraction. **Settings and Design:** This was a cross-sectional split mouth randomized controlled trial. **Materials and Methods:** The sample (30) was divided equally among the control group and the experimental group (15 each). Miniscrews were placed between second premolar and the first molar of maxilla. The experimental group was based on the split mouth technique wherein right or left side of the maxillary arch was treated using either an elastomeric power chain (EPC) engaged to the miniscrews directly (Group 1) or an EPC engaged indirectly to miniscrews with the help of SS ligature wire (Group 2). In control group, implants were placed in maxilla without any retraction force. Clinical signs of inflammation was assessed at the following interval; 7$^{th}$ day, 14$^{th}$ day, 1$^{st}$ month, 2$^{nd}$ month, and at the time of removal of implant. **Statistical Analysis Used:** Kruskal–Wallis ANOVA test was used. **Results:** Mean rank of gingival inflammation was 28.33 at the 1$^{st}$-month interval in Group 1 and inflammation remained high in the this group for all time intervals in comparison to Group 2. Group 2 showed highest mean rank of inflammation of 26.10 at 7$^{th}$ day. In control group, the inflammation remained low at all the time intervals. Moreover, the difference noted was statistically significant. **Conclusions:** The gingival inflammation around the peri-implant tissue with the application of EPC at various interval remained high in comparison to the EPC with SS group. The gingival inflammation in the control group was very less, and it remained less throughout the different time periods.

**Keywords:** *Elastomeric chain, miniscrew failure, miniscrews, orthodontic retraction, stainless steel ligature*

## Introduction

Anchorage is the resistance to unwanted tooth movement and is commonly described as the desired reaction of posterior teeth to space closure mechanotherapy to achieve treatment goals, i.e., minimum, medium, and maximum anchorage.[1]

Traditionally, orthodontists have used teeth, intraoral appliances, and extraoral appliances, to control anchorage – minimizing the movement of certain teeth, while completing the desired movement of other teeth.[2]

A temporary anchorage device is a device that is temporarily fixed to bone for the purpose of enhancing orthodontic anchorage either by supporting the teeth of the reactive unit or by obviating the need for the reactive unit altogether and which is subsequently removed after use.[3]

Inflammation of the peri-implant soft tissue has been associated with a 30% increase in failure rate. Peri-implantitis is the inflammation of the surrounding implant mucosa with clinically and radiographically evident loss of bony support, progressive mobility, bleeding on probing, suppuration, and epithelia infiltrations. Experimental studies show that an almost 9-fold increase of the risk of microscrew failure is caused by a penetrating inflammatory process, resulting in degeneration of the bone supporting the mini-implant that finally loses its stability and led to peri-mini-implantitis. Peri-micro-implantitis seems to be one of the most important factors responsible for this complication.[4,5]

Nickel–titanium closing springs and elastomeric power chains (EPCs) are commonly used for space closure alongside



**How to cite this article:** Joshi R, Shyagali TR, Jha R, Gupta A, Tiwari A, Tiwari T. Evaluation and comparison of the effect of elastomeric chain and stainless steel ligature wire on maxillary orthodontic miniscrew failure. Int J App Basic Med Res 2021;11:100-5.

**Submitted:** 10-Apr-2020
**Revised:** 17-Dec-2020
**Accepted:** 12-Jan-2021
**Published:** 08-Apr-2021

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**Access this article online**
**Website:** www.ijabmr.org
**DOI:** 10.4103/ijabmr.IJABMR_191_20
**Quick Response Code:**

active ligature tiebacks, stainless steel (SS) springs, magnets, and intermaxillary elastics.[6]

With this as background, the current study was undertaken with the aim to compare the inflammatory response in the peri-implant tissue and failure rate of maxillary miniscrews when implant is attached to EPC directly on one side and EPC attached to implant indirectly with the help of SS ligature wire on the other side.

## Materials and Methods

A cross-sectional spilt mouth randomized controlled trail was conducted in the department of orthodontics and dentofacial orthopaedics. The ethical clearance was obtained by the institutional ethical committee. The purpose of the study was briefed to all the participants and a signed informed consent was obtained for their willing participation in the study.

The study was conducted on a sample of thirty patients of age 15–30 years who were undergoing fixed orthodontic mechanotheraphy. Subjects were selected according to inclusion and exclusion criteria irrespective of the type of gender. Moreover, the selection creteria were;

Inclusion criteria were age group of 15–30 years, patients with permanent dentition, no signs of gingival inflammation before beginning of the study, none of the implants included in the study were placed in close proximity to the root surface or lamina dura, implants were placed through keratinized tissue. Exclusion criteria were patients who had used antibiotics during or 3 months before the placement of implant, patient with any systemic disease, patient having a history of periodontal disease, patient having a history of smoking, previous history of fluoride treatment, and reinsertions.

Further, the subjects were divided into three groups randomly, namely, two experimental groups (15 samples) and one control group (15 samples).The selected subjects were treated with extraction of all four premolars. Two experimental groups containing 15 samples each were formed depending on the different modes of retraction forces, applied for the retraction of maxillary anterior teeth using miniscrew as the site of delivery.

Both the control and the experimental groups were treated with fixed appliances (3M Unitek Victory series –MBT Orthodontic Metal Brackets) for anterior segment retraction after extraction of all four first premolars. All the subjects had completed the leveling and alignment stage with 0.019 × 0.025” passive SS archwire. The crimpable hooks were welded between the canine and lateral incisor on both the right and left sides. ABSCO anchor miniscrew of size 1.4 mm × 8 mm was placed in between the second premolar and the first molar using the ABSCO anchor driver. The miniscrew implant placement site was determined using implant placement guide (TNA Stent)[7] and was loaded immediately using either the power chain or the power chain with SS ligature wire depending on the two experimental sites. The power chain was stretched to provide 150 g of force on each side.[6] Exact force of stretch was determined by the dontrix gauge. All the implants were placed by single operator to minimize the placement variability.

In the experimental group (15 samples), an EPC was engaged on the crimpable hook welded between lateral incisor and canine to the main archwire and on to the implant directly (EPC group) [Figure 1]; on the second experimental group (15 samples), EPC engaged on crimpable hook and indirectly on implant with the help of SS ligature wire (EPC SS group) [Figure 2]. Both the experimental groups were in the same patients, either on the right or left side of maxillary arch.

Random allocation of the right and left side was done for engaging EPCs and EPC with SS wire for each patient.

The control group (15 samples) comprised those patients who are diagnosed of having need for critical anchorage. Among them, those patients having good axial inclination of second premolar and first or second molars and who did not show major changes in axial inclination during

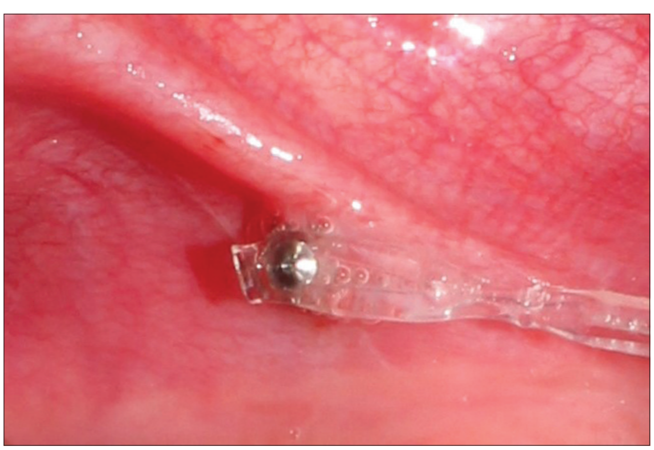

**Figure 1: Experimental Group 1 power chain group**

**Figure 2: Experimental Group 2 stainless steel ligature group**

leveling and alignment were selected. Implants were placed in leveling and alignment phase, without the application of force on them.

Patients were given oral hygiene instructions with a special protocol to be followed at the site of mini-implant region. This protocol recommended the usage of mechanical oral hygiene maintainers (tooth brush), mouthrinse with 0.12% chlorhexidine for a week after insertion of the miniscrew, and continued peri-implant hygiene with a toothbrush soaked with 0.12% chlorhexidine, until the miniscrew was removed. Periodic follow-up was done for assessment of inflammation of gingiva and mobility of microimplant.

Assessment of the clinical signs of inflammation was carried out at the following interval; 7th day, 14th day, 1st month, 2nd month, and at the time of removal of implant and the inflammation condition was scored according to the modified gingival index (mGI) given by Mombelli *et al*.,[8] which is used to assess marginal mucosal condition around the implant [Table 1]. All the assessments were done by single investigator to avoid the examination bias.

To minimize the investigation errors, all the implants were placed by the single operator, mode of retraction was also randomly allocated, and a trained calibrated investigator in the mGI had assessed the gingival inflammation around the implants. To check the intrainvestigator error, the inflammation status of gingiva was evaluated twice on ten samples within the gap of 10 min, and the data were subjected to kappa statistics which accounted for 90%.

### Statistical analysis

Data were transferred to Excel sheet (Microsoft Office 2007) and then analyzed with the help of SPSS (Statistical Package for the Social Sciences) version 22 (IBM, USA), in which Kruskal–Wallis ANOVA test was applied to find differences in gingival inflammation score between the groups at different time intervals.

## Results

Demographic data of the study sample are shown in Table 2. The study was performed on a sample of thirty participants. There were 53.3% of females and 46.7% of males in the study groups. There existed no statistical difference among the different age groups and gender.

The intergroup comparison between control group, Power chain group, and SS ligature tied to power chain group for the gingival inflammation is depicted in Table 3. The gingival inflammation is higher around power chain group with a mean rank of inflammation in between 27 and 28, whereas the mean rank of inflammation ranged from 25 to 26 in SS ligature tied to power chain group. Lowest inflammation was present in control group with the mean rank value ranging between 14 and 15. The difference noted between all the groups was statistically significant for all the time periods.

The *post hoc* Tukey honestly significant difference test for multiple comparison among the two experimental and one control group is shown in Table 4. At 7th day, mean gingival inflammation score is higher in power chain and SS ligature tied to power chain group as compared to control group with a mean difference in inflammation of −0.933, −0.867, and 0.067, which is statistically significant ($P < 0.05$). The inflammation score in control group is also more than SS ligature tied to power chain group which is not statistically significant ($P > 0.05$). At 14th day also, power chain group

**Table 1: Modified gingival index scores[8]**

| Score | Mombelli *et al*.[8] (mGI) |
|---|---|
| 0 | No bleeding when a periodontal probe is passed along the mucosal margin adjacent to the implant |
| 1 | Isolated blood spot visible |
| 2 | Blood forms a confluent red line on mucosal margin |
| 3 | Heavy or profuse bleeding |

mGI: Modified gingival index

**Table 2: Demographic data of the study participants**

| Age group (years) | Gender (%) | | Total (%) | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| | Female | Male | | | |
| 16-20 | 4 (50.0) | 4 (50.0) | 8 (100.0) | 1.6 | 0.44 |
| 21-25 | 8 (66.7) | 4 (33.3) | 12 (100.0) | | |
| 26-30 | 4 (40.0) | 6 (60.0) | 10 (100.0) | | |
| Total | 16 (53.3) | 14 (46.7) | 30 (100.0) | | |

**Table 3: Gingival inflammation around control group, elastomeric power chains (Group 1), and elastomeric power chain stainless steel (Group 2) at different time intervals**

| Time interval | Groups | *n* | Mean rank | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| 7th day | Control | 15 | 15.10 | 9.72 | 0.008* |
| | EPC | 15 | 27.80 | | |
| | EPC SS | 15 | 26.10 | | |
| | Total | 45 | | | |
| 14th day | Control | 15 | 15.67 | 8.4 | 0.015* |
| | P chain | 15 | 27.83 | | |
| | S | 15 | 25.50 | | |
| | Total | 45 | | | |
| 1st month | Control | 15 | 14.67 | 10.59 | 0.005* |
| | P chain | 15 | 28.33 | | |
| | SS | 15 | 26.00 | | |
| | Total | 45 | | | |
| 2nd month | Control | 15 | 15.93 | 7.59 | 0.022* |
| | P chain | 15 | 27.67 | | |
| | SS | 15 | 25.40 | | |
| | Total | 45 | | | |
| At the time of removal | Control | 15 | 15.93 | 7.59 | 0.022* |
| | P chain | 15 | 27.67 | | |
| | SS | 15 | 25.40 | | |
| | Total | 45 | | | |

EPC: Elastomeric power chain; SS: Stainless steel; *: <0.05

**Table 4: Mean difference in inflammation between control, elastomeric power chain (Group 1), and elastomeric power chain stainless steel (Group 2) at different time intervals**

| Time interval | Groups (I) | Groups (J) | Mean difference (I-J) | Significance | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper bound |
| 7th day | 1 | 2 | −0.933* | 0.025* | −1.77 | −0.10 |
| | | 3 | −0.867* | 0.040* | −1.70 | −0.03 |
| | 2 | 1 | | | | |
| | | 3 | 0.067 | 0.979 | −0.77 | 0.90 |
| 14th day | 1 | 2 | −0.933* | 0.028* | −1.78 | −0.09 |
| | | 3 | −0.800 | 0.067 | −1.65 | 0.05 |
| | 2 | 1 | | | | |
| | | 3 | 0.133 | 0.923 | −0.71 | 0.98 |
| 1st month | 1 | 2 | −1.067* | 0.013* | −1.94 | −0.19 |
| | | 3 | −0.933* | 0.034* | −1.81 | −0.06 |
| | 2 | 1 | | | | |
| | | 3 | 0.133 | 0.927 | −0.74 | 1.01 |
| 2nd month | 1 | 2 | −0.933* | 0.041* | −1.83 | −0.03 |
| | | 3 | −0.800 | 0.091 | −1.70 | 0.10 |
| | 2 | 1 | | | | |
| | | 3 | 0.133 | 0.931 | −0.77 | 1.03 |
| At the time of removal | 1 | 2 | −0.933* | 0.041* | −1.83 | −0.03 |
| | | 3 | −0.800 | 0.091 | −1.70 | 0.10 |
| | 2 | 3 | 0.133 | 0.931 | −0.77 | 1.03 |

CI: Confidence interval; *: <0.05

is having higher mean gingival inflammation score than other groups. Same pattern is followed till the time of removal of miniscrew implants.

## Discussion

Miniscrews have proven to be a useful addition to the orthodontist's armamentarium for skeletal anchorage in less compliant and even in noncompliant patients, but the risks involved with miniscrew placement must be clearly understood by both the clinician and the patient.[9]

Miniscrews should ideally remain stationary for applied orthodontic force, to be effective. The miniscrews stability has become a problem because it does not ground on the osseointegration, but it depends on mechanical locking of threads into the bony tissues and they consequently could hold up the orthodontic loading. Several factors contribute to the success of miniscrews which may be related to the three principle factor, namely, design factor, patient factor, and clinical factor. Age is a factor related to patient with a higher failure rate reported in adolescents as compared to adults as a result of the difference in the buccal plate thickness. Poor oral hygiene and smoking are other most common factors related to patient that reduce the survival rate of miniscrews. Insertion site and type of the mucosa (keratinized and nonkeratinized mucosa) are further patient-related factors. In general, miniscrews have been reported to have a good success rate if inserted in the maxillary region and through keratinized gingivae.[10]

Screws placed through the nonkeratinized gingiva or movable gingiva stimulate surrounding soft tissue and sometimes evoke the peri-implantitis. Cheng *et al.*[11] reported that miniscrew placement through nonkeratinized tissue sometimes caused screw failure. Moreover, the screws are often covered with surrounding movable mucosa, and it will become cause of pain and discomfort. Therefore, miniscrew's should better be implanted in the range of attached/keratinized gingiva. The screw head placed close to the mucogingival junction irritates the movable mucosa, and it becomes cause of ulcer.[12]

In the present study, only one (3.3%) implant, both in the power chain group and the power chain with SS ligature group showed high gingival inflammation and decreased stability at all the time intervals, i.e., 7th day, 14th day, 1st month, and 2nd month. Similar results were also appreciated in a meta-analysis presented by Papageorgiou *et al.*,[13] who concluded that inflammation and infection of the peri-implants tissue are not rare events and are generally considered as significant problems. Decreased implant stability is an irreversible phenomenon that can be attributed to inflammation or bone remodeling. Regular usage and meticulous oral hygiene measures are critical, and 0.2% chlorhexidine mouth rinses or dental floss dipped in 2% chlorhexidine solution can be used to prevent and control any inflammation or infection.

To minimize the failure of screw implants, inflammation around the implant must be controlled, especially for screws placed in the right side of the lower jaw.[14] Results of various other studies also show that healthy peri-implant tissue plays an important role as a biologic barrier to bacteria.[15] Tissue inflammation, minor infection, and peri-implantitis can occur after miniscrew placement. Inflammation of the peri-implant soft tissue has been associated with a 30% increase in failure rate.[16]

Other than the mini implant-related risk factors, the type of auxiliary attachment also plays a very important role. The various auxiliaries attached between the screw head and the archwire are coil springs, elastomeric chains, hooks, and ligation wires. These should be adjusted not to touch the gingiva or oral mucosa to avoid the pain and discomfort to the patient, as these factors may also contribute to peri-implant inflammation.[6]

Among these auxiliaries, elastomeric chains have shown the highest amount of plaque accumulation which may be a contributing factor for peri-implantitis.

Elastomers have been quoted as the materials that return to their original configurations. The natural rubber, earlier known as elastomer, had disadvantages with regard to their water absorption and unfavorable temperature behavior. A number of studies citing different mechanistic approaches of microbial adhesion to elastomeric ligatures have been performed. Specific lectin-similar reactions, electrostatic interactions, and Van der Waal's forces have been documented as some of the key factors responsible for the adhesion to the surfaces.[17]

In the present study, a significant mean gingival inflammation difference ($P < 0.05$) was noted between the power chain (a material having similar chemical constituent as that of elastomeric modules) and power chain with SS ligature. The power chain group showed a high gingival inflammation rank at all intervals, i.e., at 7$^{th}$ day (27.80), 14$^{th}$ day (27.83), 1$^{st}$ month (28.33), 2$^{nd}$ month (27.67), and at the time of removal (27.67). Similar results were also appreciated by Ireland *et al*.,[18] who stated that the surfaces with higher free energy have shown a favorable effect on bacterial adhesion. Moreover, there exists a close relationship between microbial colonization and surface free energy, hydrophobicity, and zeta potential of interacting surfaces.

Current results were also in accordance with the reports of Forsberg *et al*.,[19] who concluded from their study that the ligation with elastomeric rings was associated with increased microbial load compared to ligation using steel wires.

Previous studies have also shown retraction through sliding mechanics with the use of elastomeric ligatures have potential detrimental effects on dental and periodontal tissues such as decalcification and gingival inflammation, respectively.[16] When auxiliaries such as elastomeric module compared with ligature ties bacteriological findings, it is discovered that metallic ligatures slightly favor less bacterial growth. Elastic ligatures accumulate 38% more microorganisms in the form of plaque when compared to metallic ligatures. As the elastomeric chain is also made up of the same chemical composition, we anticipate the elastomeric chains will tend to accumulate more plaque in comparison to SS ligature ties, leading to more inflammation which might be a contributing factor for miniscrew implant failure.[17]

The intergroup comparison between control group, elastomeric power chain group, and SS ligature tied to power chain group for the gingival inflammation showed that gingival inflammation is higher around power chain group with a mean rank of 27.80, followed by SS ligature tied to power chain group (26.10) at 7$^{th}$ day. Lowest inflammation is present in control group (15.10). Similar results were seen in a study done by Forsberg *et al*.[19] who reported that, in the majority of patients, the incisor which was attached to the archwire with an elastomeric ring, exhibited a greater number of microorganisms in the plaque than the incisor ligated with steel wire. Our results were in disagreement with the study done by Turkkahraman *et al*.,[20] who concluded that no significant effect of archwire ligation technique was determined in the gingival index and probing depths of bonded teeth. However, the teeth which were ligated with elastomeric rings were more prone to bleeding. Therefore, the use of elastomeric rings is not recommended in patients with poor oral hygiene. However, our results were in contrast with the study done by Sukontapatipark *et al.* (2001),[21] who concluded that the method of ligation does not affect the plaque accumulation and gingival inflammation. The results of the previous studies also conclude that elastomeric ligatures showed a significant lower susceptibility to plaque adhesion, in comparison to the SS or the metallic ligatures.

The inflammation in the peri-implant tissue in the power chain group was found to increase during different intervals. The mean gingival inflammation rank at 7$^{th}$ day, 14$^{th}$ day, 1$^{st}$ month, and 2$^{nd}$ month where 27.80, 27.83, 28.33 , 27.67, and 27.67, respectively. The results of the current study were similar to the findings of the study conducted by Mavani *et al*.,[22] who reported that there was statistically significant rise in the microbial colonization of *Streptococcus mutans* and *Lactobacilli* during orthodontic treatment at different intervals of time, i.e., 1$^{st}$, 5$^{th}$, and 8$^{th}$ week in elastomeric module.

Although, literature on the plaque accumulation on the elastomeric modules and the SS ligature tie is plenty, the relation of these two materials, namely, SS and the elastomeric material on the status of the peri-implant tissue is rare. Thus, the current study is unique as it investigated the influence of elastomeric chain and the SS wire on the accumulation of microbial flora and causing subsequent gingival inflammation at the peri-implant site.

Although the rate of miniscrew implant is not affected by the type of auxiliary interface, it definitely affects the peri-implant tissue. The results of our study showed that inflammation in the peri-implant tissue was noted more so in power chain group. Further, the study was limited to subjective assessment of gingival condition using the inflammation index. Thus, the study carries a future scope to perform microbial cultures research to substantiate the current results.

## Conclusions

The gingival inflammation around the peri-implant tissue with the application of EPC at various intervals remained high in comparison to the EPC with SS group. Thus, clinicians should opt EPC attached with the aid of SS to miniscrew to reduce the severity of gingival inflammation.

The gingival inflammation in the control group was very less, and it remained less throughout the different time periods, suggesting that the EPC whether attached directly or through aid of the SS to the miniscrew acted as a nidus of the microorganism leading to the gingival inflammation.


### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.


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