In-vitro Comparison of Tensile Strength of Commonly Used Suture Materials for Oral and Periodontal Surgeries by simulating Oral Environment

Nawaf Hassan Alamer¹, Raed Mofarh Alkhulban¹, Shahabe Saquib Abullais²*, Weam Ibrahim³, Mohammad Yunis Saleem Bhat⁴ and Muhammad Farhan Khan⁵,⁶

¹Interns, College of Dentistry, King Khalid University, Abha, 61321, KSA; ²Periodontics and Community Dental Sciences, College of Dentistry, King Khalid University, Abha, 61321, KSA; ³Department of Prosthodontics, Baqai Dental College, Karachi, Pakistan; ⁴Department of Prosthetic Dentistry, College of Dentistry, King Khalid University, Abha, KSA

Abstract

Objectives: The present in vitro study sought to evaluate the effect of saliva on the tensile strength of the commonly used suture material over a period of two weeks. Three suture materials Silk (SL), polyglactin 910 (PG) and polypropylene (PP) were used in 4-0 gauge. Methods: A total of 120 suture samples (40 from each material) were used for the experiment. Artificial saliva was mixed with human serum in 1:1 to simulate oral environment. All samples were tested at pre-immersion (baseline), 3rd, 7th and 14th day post-immersion period. Universal testing machine was used to test the selected mechanical properties. Results: The percentage of mean baseline tensile strength was significantly higher in PP group (P-value<0.001). Inter-group comparison revealed that PP group has maximum tensile strength when compared with PG and SL groups at all point of time. Intra-group comparison showed that all the three suture materials had significant difference in mechanical properties when pre-immersion values were compared with 14th day post-immersion values (P-value<0.001). Conclusion: PP sutures are strongest and have highest tensile strength and elongation property. PP seems to sustain its tensile strength better than SL and PG at the end of 14th day. Planned clinical experiments are necessary to verify this finding in an in-vivo setting.

Keywords: Silk; Polyglactin 910; Polypropylene; Periodontal surgery; Tensile strength

Introduction

The number of needed surgeries worldwide is increasing every day. One of the main success factors is the proper selection of the suture type. The ideal suture material should not breakdown suddenly while in use, have proper elongation property, biocompatible, easily to handle, able to form a secure knot, and, biodegrade in an appropriate situations. [1] This on the other hand depends on several factors, including the mechanical properties of the suture materials.

Oral suturing is unlike suturing in other parts of the body due to the constant presence of saliva, high tissue vascularization, and functions related to speech, mastication, and swallowing. [2] Suitable sutures require precise physical characteristics and properties. One of the most important mechanical properties is the tensile strength of the suture material. The tensile properties, elasticity and stiffness of the suture material are some of the factors that control the function of the suture while in clinical use. [3]

The key importance of suturing after surgery is to keep the flap edges in close opposition to provide a primary closure. Failure to attain primary closure and preserve it over the early healing phase can be harmful to the desired outcome of the surgical procedure. Tensile strength is a characteristic that required to be upheld due to the fact that suture material tends to lose between 70% and 80% of its original strength. Consequently, the necessary original tensile strength must be guaranteed to avoid breaking the suture material. [4,5] Therefore, a deficit in the resistance of the suture material can lead to untimely rupture of the suture, which can lead to incapable adaptation of the surgical flaps and the healing by second intention. [6] The comprehensive studies that are available on sutures materials are much less relevant to materials used for oral and periodontal surgical procedures. [7,8]

In the oral cavity, different suture materials show different behaviors. [9-11] amongst the several available suture materials, silk, polyglactin are commonly used in oral and periodontal procedures. Silk is the most commonly used natural suture material, due to its superior handling characteristics. [12] Three different suture materials were included in the present study (Silk which consider by many surgeon as gold stone due to it easy handling. [12] Polyglactin 910 (Vicryl) is a multifillament absorbable synthetic coated suture composed of a copolymer made from 90% glycolide and 10% L-lactide and Polypropylene monofilament, non-absorbable which composed of an isotactic crystalline isomer of polypropylene.

Therefore, the aim of the current study is to evaluate and compare the tensile strength of silk, Polyglactin 910 and polypropylene suture material in an orally simulated environment (immersed in artificial saliva) and a pre-immersed dry condition during a period of fourteen days.
Materials and Methods

The present in-vitro study protocol was reviewed and approved by the King Khalid University Ethical Review Committee (ERC), Abha, Saudi Arabia with approval no [SRC/ETH/2017-18/090]. The study was conducted in period of August 2018 to September 2018. Three different types of suture materials were selected and their physical properties were evaluated in the current study [Table 1 and Figure 1]. Suture materials were divided into control (pre-immersed) and test group (immersed in artificial saliva). All the test suture materials were exposed to thermo-cycling (alternate temperature change from 5°C to 55°C), so as to simulate the challenges in the oral cavity.

A total of 120 suture samples were collected from commercially available stocks. Forty samples were obtained from each suture material type. All the suture samples were measured to a uniform length of 18 cm. Ten specimen from each group were tested for tensile strength before immersing into artificial saliva and referred as control group. Remaining suture specimens were kept in artificial saliva until exposed to experimental procedure. The complete study protocol has been described in detail in the Figure 2 (Flow chart).

Artificial saliva was formulated by mixing the compounds shown in Table 2 in one liter of distilled water. To prevent any chemical changes in the prepared mixture, it was kept secured in an amber color bottle until used for the experiment. During the experiment, the prepared artificial saliva was mixed with Human serum in 1:1 concentration, to simulate oral environment. This biologic mixture was kept at a pH of 7.4 to 8.1 in an incubator at 37°C.

Mechanical properties of the suture samples were evaluated by using universal testing machine (Quasar 100, Schutz-Licht, Langenfeld, Germany) coupled to a computer for digital productivity. Tensile strength of the suture samples were checked at particular time period: pre-immersion (dried), 3rd, 7th and 14th days post-immersion into artificial saliva. Each suture sample was fixed around two metal hooks attached to the opposite arms of the universal testing machine with a preset distance of 18 cm. Pilot testing revealed that this type of experimental setup did not result in the suture sample failure at the hooks or at the knots. Measurements were recorded for tensile strength. Tensile Strength is the maximum load that can be applied to a suture material before the suture breaks and it is measured in the unit of Newtons (N).

The data on continuous variables is presented as mean and standard deviation (SD) across the study groups. Statistical test Analysis of Variance (ANOVA) was used for the inter-group and intra-group comparison. In the entire study, the p-values less than 0.05 were considered to be statistically significant. The entire data is statistically analyzed using Statistical Package for Social Sciences (SPSS version 21.0, IBM Corporation, USA) for MS Windows.

Results

All the suture materials were intact without any visual deterioration during and at the end of the soaking period in saliva. Each suture specimen showed and evident breaking point while testing on universal testing machine. Baseline (pre-immersion) comparison of mean tensile strength is presented in Table 3. The distribution of mean baseline strength was significantly higher in PP group followed by PG group and the least with SL group (P-value<0.001 for all).

Table 4 is showing the distribution and comparison of mean tensile strength among three suture groups at 3rd, 7th and 14th day post-immersion in the saliva. PP group was exhibiting the

<table>
<thead>
<tr>
<th>Suture material</th>
<th>Brand</th>
<th>Degradation</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk (SL)</td>
<td>Mersilk®</td>
<td>Non-Absorbable</td>
<td>Ethicon, Johnson &amp; Johnson Pvt. Ltd. India.</td>
</tr>
<tr>
<td>Polyglactin 910 (PG)</td>
<td>Vicryl®</td>
<td>Absorbable</td>
<td>Ethicon, Johnson &amp; Johnson Pvt. Ltd. India.</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>Prolene®</td>
<td>Non-Absorbable</td>
<td>Ethicon, Johnson &amp; Johnson Pvt. Ltd. India.</td>
</tr>
</tbody>
</table>

Figure 1: Suture materials used in the study.
maximum tensile strength when compared with PG and SL groups at all point of time (P-value<0.001).

Table 5 presented intra-group comparison of different suture material with respect to tensile strength from pre-immersion to 14th day post-immersion period. All the three suture material showed significant difference in strength when mean values from baseline (pre-immersion) is compared with 14th day post-immersion period.

**Discussion**

In the past, materials like animal hair, natural fibers, silk, nylon and gut mucosa have been used to close the surgical wounds. A surgeon always looks for good handling characteristics and tensile strength of a suture while selecting a suture material. The tensile strength of a suture material is an indispensable property due to which suture material tolerates the tissue tension at the flap margin. Suture materials exhibiting low tensile strength are more vulnerable to breakage during the healing period because of tension created by edema and tissue tension. Different type of suture materials having the same diameter size may varies drastically in their tensile strengths measurement. In the literature most of the documented studies on mechanical

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**Table 2:** Chemical composition of artificial saliva.

<table>
<thead>
<tr>
<th>Chemical components</th>
<th>Concentration (gm/L)</th>
</tr>
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<tbody>
<tr>
<td>Sodium chloride (NaCl)</td>
<td>0.125</td>
</tr>
<tr>
<td>Potassium chloride (KCl)</td>
<td>0.963</td>
</tr>
<tr>
<td>Potassium thiocyanate (KSCN)</td>
<td>0.189</td>
</tr>
<tr>
<td>Monopotassium phosphate (KH₂PO₄)</td>
<td>0.654</td>
</tr>
<tr>
<td>Urea (CH₂N₂O)</td>
<td>0.200</td>
</tr>
<tr>
<td>Sodium sulfate decahydrate (Na₂SO₄·10H₂O)</td>
<td>0.763</td>
</tr>
<tr>
<td>Ammonium chloride (NH₄Cl)</td>
<td>0.178</td>
</tr>
<tr>
<td>Calcium Chloride Dihydrate (CaCl₂·2H₂O)</td>
<td>0.227</td>
</tr>
<tr>
<td>Sodium bicarbonate (NaHCO₃)</td>
<td>0.630</td>
</tr>
</tbody>
</table>

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properties of sutures are performed on skin and subcutaneous tissues. In such experimental design, sutures were exposed to limited environmental elements that can influence physical and mechanical properties of the sutures. Studies involving oral cavity poses multiple challenges like; presence of saliva, reflux gastric juice, pressure from the surrounding soft tissues and occlusal forces that may significantly modify the properties of suture materials. Previous studies on PG sutures revealed excellent handling characteristics,, high initial tensile strength, and less tissue reactions while healing. A strong relationship between suture degradation and tensile strength has been reported in the literature under controlled in vitro and in vivo settings. PG degradation in-vivo is mainly due to proteolytic enzymatic degradation. PG sutures retained more than two-thirds of their original tensile strength at the 14 day post-immersion period. The findings of the current study also revealed that more than two-thirds of the original tensile strength is retained at 14th day post immersion. According to the findings of the other study, when PG was exposed to saliva, showed more rapid tensile strength loss, especially after 7 days. This finding is contradictory to the finding of the current research. SL is the most commonly used suture material in the surgical field even though it carries suboptimal mechanical properties. Although SL is classified as a non-resorbable suture, but recognized to be subject to proteolytic degradation over a longer period. Studies have shown that SL is one of the most susceptible sutures to variation in pH conditions. In the current study it was reported that mechanical properties of SL suture were decreases at 14th post immersion period. These findings are in agreement with the respite presented by Banche et al. where tensile strength of SL decreased upon exposure to saliva.

### Conclusion

The present study affirms that the suture a material tends to lose a significant amount of tensile strength when exposed to oral environment. PP suture showed highest mechanical properties when compared with the PG, and SL suture. Under the limitation of the present study authors conclude that PP is best suture material for wound closure after oral and periodontal surgical procedure followed by PG and SL respectively.
Competing Interests

The authors declare that they have no competing interests.

References


