ORIGINAL RESEARCH

In Vitro Assessment of Tensile Strength of Surgical Suture Materials

Suhas R Nayak[1], Ajay Kumar Haridas[2], Lin Jacob Varghese[3], M Mubasheer[4], Tarun Nanu[5], P V Nithin[6]

ABSTRACT

Background: Suturing in dentistry is different from suturing in the other parts of the body because of the type of tissues involved, the constant presence of saliva, high tissue vascularization, and functions related to speech, mastication, and swallowing. Appropriate sutures require specific physical characteristics and properties, such as good tensile strength, dimensional stability, and lack of memory, knot security, and sufficient flexibility to avoid damage to the oral mucosa. Hence, the present study was conducted with an aim to assess the tensile strength of different surgical suture materials.

Materials and Methods: This study consisted of three different types of absorbable suture materials (polyglycolic acid, chromic gut, and polyglyconate) with two gauges (4–0 and 5–0) of each type which were used. Surgeon's knot was used to tie around a flexible rubber tubing, that allows for a consistent loop size that would be practical during the mechanical analysis phase. A total of 120 suture specimens (20 of each material and gauge) were used in the present study. All the samples were immersed in the artificial saliva to stimulate the oral environment. The tensile strength of the suturing materials was tested at pre-immersion and 1st, 7th, and 14th days of post-immersion. A universal testing machine was used to record the tensile strength of suturing materials.

Results: The 4–0 gauges of polyglycolic acid and chromic gut suturing material show greater tensile strength compared to 5–0 gauge material. Moreover, there was a statistically significant difference found at pre-immersion, 1st day, and 7th day. The greater tensile strength of polyglyconate 4–0 gauge was found on pre-immersion state. Moreover, there was a statistically significant difference found at pre-immersion and 1st day.

Conclusion: All 4–0 suture materials were stronger and had greater tensile strength than 5–0 suture materials. Chromic gut showed a sustain strength better than polyglycolic acid and polyglyconate suturing materials after 14 days.

Keywords: Absorbable, Biodegradation, Suture materials, Tensile strength.

How to cite this article: Nayak SR, Haridas AK, Varghese LJ, Mubasheer M, Nanu T, Nithin PV. *In Vitro* Assessment of Tensile Strength of Surgical Suture Materials. Int J Oral Care Res 2018;6(1):S12-15.

Source of support: Nil

Conflicts of interest: None

[1,3]Reader, [2]Professor and Head, [4-6]Senior Lecturer

[1-6]Department of Oral and Maxillofacial Pathology, Educare Institute of Dental Science, Chattiparamba, Malappuram, Kerala, India

Corresponding Author: Dr. Suhas R. Nayak, Reader, Department of Oral and Maxillofacial Pathology, Educare Institute of Dental Science, Chattiparamba, Malappuram, Kerala, India. e-mail: suhasnayak83@gmail.com

INTRODUCTION

The function of sutures is to hold tissue in apposition and to support the tissue in opposing all physiological forces during the period of healing. Different tissues require a different period of healing to achieve the sufficient strength. For an organ that contains free hydrochloric acid and potent proteolytic enzymes, the stomach and intestines heal surprisingly quickly. Stomach and intestine wounds attain maximum strength within 14–21 days postoperatively and have a peak rate of collagen synthesis at 5 days. In that period, collagen formation increases tissue strength, while the tensile strength of implanted sutures gradually decreases.[1]

Suturing in dentistry is different from suturing in the other parts of the body because of the type of tissues involved, the constant presence of saliva, high tissue vascularization, and functions related to speech, mastication, and swallowing. Appropriate sutures require specific physical characteristics and properties, such as good tensile strength, dimensional stability, lack of memory, knot security, and sufficient flexibility to avoid damage to the oral mucosa.[2]

A range of sutures is available which are classified by several criteria: (1) Composition -natural and synthetic, (2) structure - monofilament and multifilament, and (3) spontaneous degradation - absorbable and non-absorbable.

One of the advantages of absorbable sutures is that they generally do not need to be removed. However, those materials are associated with different tissue responses as a result of their degradation by hydrolysis, enzymatic digestion, or phagocytosis. The rate or this degradation depends on the pH and the temperature of the tissues surrounding the suture.[3]

The selection of appropriate suture material is a critical step that is based on appropriate tensile strength, tissue biocompatibility, and resorption rates. In the dental literature, there seems to be a greater emphasis on tissue response to suture materials than on the assessment of the physical and biochemical properties of the suture materials.[4,5]

An in-depth understanding of the physical and mechanical properties of suture materials is crucial to dental practice. However, there is incomplete and inconsistent information regarding tissue reactions to different suture materials.[6] Hence, the present study was done to evaluate and compare the tensile strength of three different suture materials.

MATERIALS AND METHODS

The present study consisted of three different types of absorbable suture materials (polyglycolic acid, chromic gut, and polyglyconate) with two gauges (4–0 and 5–0) of each type were used. The materials and gauges were selected based on common usage in dental surgery.

Suturing Technique

Surgeon's knot was used to tie around a flexible rubber tubing, that allows for a consistent loop size that would be practical during the mechanical analysis phase. Once tied, the sutures were carefully slid off the tubing for testing. A total of 120 suture specimens (20 of each material and gauge) were used in the present study. All the samples were immersed in the artificial saliva to stimulate the oral environment.

Preparation of Artificial Saliva

Preparation of artificial saliva was done by mixing 100 mL each of 25 mM K2HPO4, 24 mM Na2HPO4, 1570 mM KHCO3, 100 mM NaCl, and 1.5 mM MgCl2, followed by adding 6 ml of 25 mM citric acid and 100 mL of 15 mM CaCl2. The pH was adjusted to 6.7 with 5 N NaOH or concentrated (12 N) HCl. The solution was sterilized by autoclaving,[7] and this was thermostatically controlled at 37 ± 1°C during the immersion/exposure periods.

Testing Procedure

The tensile strength of the suturing materials was tested at pre-immersion and 1st, 7th, and 14th days of post-immersion. The universal testing machine was used to record the tensile strength of suturing materials. Each sample was taken from the container containing the artificial saliva, and the suture was positioned with the knot pointed midway between both arms to allow for consistency in force distribution relative to the knot. Tensile strength assessment of the suture samples was done at a cross-head speed of 25 cm/min. Each specimen was stretched to failure, and the maximum load was recorded in Newton (N) and tabulated for analysis. The point of breakage for each sample of each material was assessed at a magnification of ×100 using a microscope with an attached digital camera.

Statistical Analysis

SPSS software version 20.0 was used for data analysis. Analysis of variance test was used to compare the data between and within the groups. $P < 0.05$ is statistically significant.

RESULTS

Table 1 shows the comparison of two gauges of polyglycolic acid suturing material tensile strength with different time intervals. 4–0 gauges suturing material show greater tensile strength compared to 5–0 gauge material. Maximum tensile strength of 4–0 gauge was on 1st day (13.88 ± 0.64) and in 5–0 gauge at pre-immersion state (7.34 ± 0.54). Moreover, there was a statistically significant difference found at pre-immersion, 1st day, and 7th day.

Table 2 depicts the comparison of two gauges of chromic gut suturing material tensile strength with different time intervals. 4–0 gauges suturing material show greater tensile strength compared to 5–0 gauge material. Maximum tensile strength of 4–0 gauge was on 1st day (13.98 ± 1.10). and in 5–0 gauge at pre-immersion state (9.04 ± 1.22). Moreover, there was a statistically significant difference found at pre-immersion, 1st day, and 7th day.

The greater tensile strength of polyglyconate 4–0 gauge was found on pre-immersion state (12.40 ± 1.92) and in 5–0 gauge on 1st day (8.97 ± 0.42). Moreover, there was a statistically significant difference found at pre-immersion and 1st day [Table 3].

DISCUSSION

To minimize the variability, single examiner was carried out the entire research. The methodology used for this study was established according to previous studies. The universal testing machine was configured based on parameters set by Kim *et al*.[3] Moreover, artificial saliva was used in this study accordance with Soderholm *et al*.[7] who observed statistically significant differences in the degradation of various suture materials.

Synthetic absorbable suture materials provide a temporary and mechanical support until the natural tissue heals and regains its strength. As the natural tissue heals, the degradable suture gradually weakens so that a gradual stress transfer occurs. Therefore, adjusting the rate of degradation of an absorbable suture to enable proper healing of the surrounding tissue is a major challenge in designing a temporary support. Clinically, most absorbable sutures are made of biodegradable

Table 1: Comparison of two gauges of polyglycolic acid suturing material tensile strength with different time intervals

Time interval	Polyglycolic acid suturing material		*P* value
	4–0 Tensile strength	5–0 Tensile strength	
Pre-immersion	13.41±1.98	7.34±0.54	0.001
1st day	13.88±0.64	7.02±0.32	0.001
7th day	8.12±1.75	4.23±0.44	0.03
14th day	3.43±1.79	2.90±0.23	0.42

Table 2: Comparison of two gauges of chromic gut suturing materials tensile strength with different time intervals

Time Interval	Chromic gut suturing material		*P* value
	4–0 Tensile strength	5–0 Tensile strength	
Pre-immersion	13.90±1.04	9.04±1.22	0.001
1st day	13.98±1.10	8.97±0.73	0.001
7th day	9.14±1.12	3.11±0.23	0.02
14th day	4.91±1.62	3.98±0.38	0.80

Table 3: Comparison of two gauges of polyglyconate suturing materials tensile strength with different time intervals

Time interval	Polyglyconate suturing material		*P* value
	4–0 Tensile strength	5–0 Tensile strength	
Pre-immersion	12.40±1.92	8.20±1.96	0.001
1st day	11.98±0.43	8.97±0.42	0.001
7th day	4.14±1.78	3.78±0.39	0.09
14th day	1.31±0.12	0.98±0.20	0.80

linear aliphatic polyesters, of which polyglycolic acid is the most important because most other biodegradable polymers are derived from polyglycolic acid.[8] In the present study, sutures made of polyglycolic acid and other degradable polymers were investigated. polyglycolic acid is absorbed by the body through a mechanism of biodegradation which is similar to the study done by Khiste *et al*.[9]

The surgeon's knot was used in this study because it is the most widely used type in dental surgery. Moreover, this kind of knot has been previously employed in various studies conducted by Selvig *et al*.[10] and Yaltirik *et al*.[11]

In this present study, results showed that chronic gut sutures maintained their tensile strength in a relatively stable manner over the study period. Of the three suture materials used in this study, the chromic gut sutures had the highest tensile strength at baseline, but it decreased gradually over time. This contradicts the findings of Brown[12] that polyglycolic acid sutures have excellent knot-holding capacity and tensile strength. Freudenberg *et al*.[13] stated when it is used intraorally, a surgical gut suture loses most of its tensile strength in 24–48 h unless it is treated with a chromic compound that extends the period of resorption for 7–10 days and delays the loss of tensile strength for up to 5 days. Chromic gut sutures maintain their tensile strength for 10–14 days and do not completely absorb until at least day 90. However, the inferior handling properties, tissue drag, and higher rate of inflammation in the surrounding tissues have made gut sutures less desirable.[14]

In the present study, chromic gut shows the greater tensile strength than polyglycolic acid and polyglyconate suturing materials. In the saliva solution, the chromic gut sutures maintained their tensile strength for the first 24 h, but a significant reduction in the tensile strength was noted until day 14.[15]

The study demonstrated that the 4–0 sutures were stronger and had greater tensile strength than the 5–0 sutures for all of the three materials. The present study noted that the sutures were not tested *in vivo* and that values might be different. Further study has to be conducted to evaluate the yield point or elastic limit of these sutures as well as their responses to repeated cycles of stress.

CONCLUSION

All 4–0 sutures materials were stronger and had greater tensile strength than 5–0 suture materials. Chromic gut showed a sustain strength better than polyglycolic acid and polyglyconate suturing materials after 14 days. Clinical *in vivo* studies are required to confirm these findings.

REFERENCES

1. Kreszinger M, Toholj B, Ačanski A, Sebastijan B, Marko C, Pećin M, *et al*. Tensile strength retention of resorptive suture materials applied in the stomach wall-*in vitro* study. Vet Arhiv 2018;88:235-43.
2. La Scala G, Lleo MM. Sutures in dentistry. Traditional and PTFE materials (in Italian). Dent Cadmos 1990;58:54-8.
3. Kim JC, Lee YK, Lim BS, Rhee SH, Yang HC. Comparison of tensile and knot security properties of surgical sutures. J Mater Sci Mater Med 2007;18:2363-9.
4. Parirokh M, Asgary S, Eghbal MJ, Stowe S, Kakoei S. A scanning electron microscope study of plaque accumulation on silk and PVDF suture materials in oral mucosa. Int Endod J 2004;37:776-81.
5. Otten JE, Wiedmann-Al-Ahmad M, Jahnke H, Pelz K. Bacterial colonization on different suture materials-a potential risk for intraoral dentoalveolar surgery. J Biomed Mater Res B Appl Biomater 2005;74:627-35.
6. Abellán D, Nart J, Pascual A, Cohen RE, Sanz-Moliner JD. Physical and mechanical evaluation of five suture materials on three knot configurations: An *in vitro* study. Polymers 2016;8:1-9.
7. Soderholm KJ, Mukherjee R, Longmate J. Filler leachability of composites stored in distilled water or artificial saliva. J Dent Res 1996;75:1692-9.

8. Huang TW, Cheng PW, Chan YH, Wang CT, Fang KM, Young TH. Clinical and biomechanical analyses to select a suture material for uvulopalatopharyngeal surgery. Otolaryngol Head Neck Surg 2010;143:655-61.
9. Khiste SV, Ranganath V, Nichani AS. Evaluation of tensile strength of surgical synthetic absorbable suture materials: An *in vitro* study. J Periodontal Implant Sci 2013;43:130-5.
10. Selvig KA, Biagiotti GR, Leknes KN, Wiskejo UM. Oral tissue reactions to suture materials. Int J Periodontics Restor Dent 1998;8:475-87.
11. Yaltirik M, Dedeoglu K, Bilgi B, Koray M, Ersev H, Issever H, *et al*. Comparison of four different suture materials in soft tissues of rats. Oral Dis 2003;9:284-6.
12. Brown RP. Knotting technique and suture materials. Br J Surg 1992;79:399-400.
13. Freudenberg S, Rewerk S, Kaess M, Weiss C, Dorn-Beinecke A, Post S. Biodegradation of absorbable sutures in body fluids and pH buffers. Eur Surg Res 2004;36:376-85.
14. Vasanthan A, Satheesh K, Hoopes W, Lucaci P, Williams K, Rapley J. Comparing suture strengths for clinical applications: A novel *in vitro* study. J Periodontol 2009;80:618-24.
15. Moser JB, Lautenschlager EP, Horbal BJ. Mechanical properties of polyglycolic acid sutures in oral surgery. J Dent Res 1974;53:804-8.