Original Article

Effect of Hyaluronic Acid in Modifying Tensile Strength of Nonabsorbable Suture Materials: An *In Vitro* Study

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ABSTRACT

Background and Aims: In periodontics and other surgical disciplines, sutures play a detrimental role in healing of wound. The use of chemical adjuncts to boost healing has been experimented in recent years. The aim of this study was to evaluate the role of hyaluronic acid rinse in influencing the tensile strengths of commonly used sutures. **Materials ad Methods:** Two commonly used nonabsorbable suture materials, silk and polyamide, were used for this *in vitro* study. Tensile strengths of the suture materials were determined by pre- and post-immersion in hyaluronic acid (test) and chlorhexidine (control). A Tinius Olsen Universal Testing Machine was used to assess the tensile strength of the samples. The variables were assessed for normality using the Kolmogorov–Smirnov test. The Wilcoxon signed rank test and Mann–Whitney *U* test (for quantitative data within two groups) were used for quantitative data comparison of all the clinical indicators. The level of significance was set at $P \leq 0.05$. **Results:** Polyamide showed better stability in terms of tensile strength when compared to silk. Hyaluronic acid as a chemical adjunct did not alter the tensile strengths of both suture materials pre- and post-immersion. **Conclusion:** This *in vitro* study has shown a promising property of hyaluronic acid with relation to stabilization of tensile strength of suture materials, which needs to be evaluated in clinical settings.

KEYWORDS: *Chlorhexidine, hyaluronic acid, in vitro, nonabsorbable sutures, polyamide, silk, tensile strength*

INTRODUCTION

Sutures are used for various treatment modalities in surgical disciplines. They form the fabric to approximate and ligate tissues, control hemorrhage, and also assist in primary healing process.[1] The use of sutures, both resorbable and non-resorbable, in surgical specialties such as periodontics and oral surgery, depends on the type of surgical procedure performed. The predictability depends on many factors such as diameter of the suture material, thread type, and knot security.[2] Sutures need to possess certain characteristics such as good memory, dimensional stability, and adequate tensile strength, to be sustainable for the intended duration of the treatment.[3] Sutures are available depending on their specific characteristics such as material degradation (absorbable and nonabsorbable), their composition (natural and synthetic), structure (monofilament and multifilament), the thread (normal and swaged), and their various diameters.[4]

Monofilament and multifilament sutures are commonly used in various periodontal and oral surgical procedures. Monofilament sutures show lower tissue drag and lower risk of infection compared to the braided materials, but the polished ends can be a source of irritation.[5] Multifilaments are more easier to handle owing to their bending property which is considerably

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low. Due to their braided nature they attract food, debris and bacteria is what is coined "wicking effect" which can result in post operative inflammation.[6] Silk is a natural nonabsorbable braided suture material, which has been used in routine surgical procedures. Though silk possesses various advantages such as ease of handling, low bending stiffness, and less tissue drag, it has one major disadvantage, which is its ability to attract bacteria and debris because of which the inflammatory component of the tissue tends to remain for longer periods.[6]

Various chemicals have been added to the silk material to overcome the so-called "wicking effect." Recently, chitosan was coated onto the silk surface.[7] Silver-doped bioactive glass powder was also attempted.[8] A more recent attempt was to coat silk with a natural fungal extract.[9] Polyamide is a synthetic, monofilament, and nonabsorbable suture, which is used in periodontal and oral surgical procedures as it shows lower knot tie-down resistance, lower tissue drag, and less stiff resistance compared to multifilament and braided material such as silk.[1,10]

The property of tensile strength has been evaluated in various studies in an *in vitro* and animal model.[11] Tensile strength is lost for most sutures over a period with a range between 10% and 90% over a time frame between 10 and 90 days. This property varies between absorbable and nonabsorbable suture material.[12] Periodontal and oral surgical treatment follow-ups routinely advocate the use of mouth rinses, such as chlorhexidine (CHX), and also anti-inflammatory, tissue-firming gels, such as hyaluronic acid (HA). CHX is a bisbiguanide antiseptic with confirmed antibacterial activity. It has been used for the last 70 years. Extensive literature has been written on the use of CHX in dental, surgical, and gynecological settings.[13-15] HA rinses have been recently given to patients after surgical procedures for wound closure and to promote healing. HA is advocated as highly biocompatible and nonimmunogenic, which further advocates its use in surgical procedures. Pagnacco *et al.*[16] have highlighted its anti-inflammatory and antibacterial property.

The aim of this study was to evaluate the effect of CHX and HA rinses on the tensile strengths of selected nonabsorbable suture materials.

Materials and Methods

Study design

The study was evaluated by the ethical committee for any ethical issues, since the study design was in-vitro. It was granted exemption from ethical clearance, (Ref no: UGD-L-18-12--19-34). The protocols for the study was further registered in protocols. (Ref details-dx.doi.org/10.17504/protocols.io.2f2gbqe) It was completed in two months and was carried out in a heavy duty testing center that specialized in evaluating tensile strengths. Two nonabsorbable suture materials were exposed to two different media (one control and one test) in *in vitro* settings and thermostatically controlled environment. The temperature was maintained at a mean value of 38°C. The suture materials were evaluated for tensile strength at pre-immersion and later at 24 h post-immersion in the selected medium.

Study materials

Tested suture materials were obtained from sterile, unexpired packets. They were 3-0 Mersilk (Ethicon, Somerville, New Jersey) and 2-0 Ethilon (Polyamide 6; Ethicon).

Two experimental media, which were placed in a thermostatically controlled environment, were used for exposure to suture materials: control group—Curasept ADS Mouthwash, (Curaden, Kriens, Switzerland) and test group—HA rinse (0.2% HA, 7.5% Xylitol; Ricerfarma S.R.L., Milano, Italy).

Testing method

Fifteen samples were taken of both the suture materials, which accumulated to a total of 30 samples (n = 30). The suture materials were measured to 30 cm in length. The first suture material (n = 5) was tested for tensile strength at pre–immersion, which was calculated in Newton per millimeter square (N/mm^2). The photo of the machine testing the suture materials was not taken. Only the photos of the suture in the solutions and the machine itself is there.

A Tinius Olsen Universal Testing Machine, model no. 50 ST (Tinius Olsen, Surrey, UK), was used to assess the tensile strength of the samples. The testing was carried out with an initial load cell capacity calibrated at 50 N for pre-immersion. The testing speed to standardize the tensile strength determination for each sample was placed at 2 mm/min to avoid any structural damage to the suture material. The length of the specimen was benchmarked at 30 cm. Tensile strength was determined pre-immersion with a single pull till fatigue or failure sets in. For post-immersion, load cell was raised gradually to 100 N and was recorded as the maximum load-bearing value.

Statistical analysis

The data were coded and entered into Microsoft Excel spreadsheet. Analysis was carried out using the Statistical Package for the Social Sciences software

program, version 20 (IBM SPSS Statistics, Chicago, Illinois), for Windows. The Wilcoxon signed rank test and Mann–Whitney *U* test (for quantitative data within two groups) were used for quantitative data comparison of all the clinical indicators. The level of significance was set at $P \leq 0.05$.

Results

Table 1, comparing the mean and standard deviations for CHX and HA rinses on polyamide suture material, shows a varied picture. At baseline, pre-immersion, the mean value of polyamide was 354 N/mm^2, this value reduced significantly ($P < 0.04$) after 24 h when placed in CHX. The mean value (331 N/mm^2) did not show any significance ($P > 0.08$) when placed in HA rinse.

Table 2 shows significant values with relation to CHX and HA rinses at $P = 0.001$ and $P = 0.008$, respectively. The results showed that the mean tensile strength of polyamide at pre-immersion was 1035.2 N/mm^2, which got lowered to 450 N/mm^2 after 24 h, which showed significant decrease. The tensile strength of silk with relation to immersion in CHX also showed a significant decrease from 1035.2 to 458 N/mm^2 at post-immersion with a significance of $P < 0.001$.

On evaluating the intergroup comparison using the Mann–Whitney *U* test [Table 3], it was found that the mean values varied for all rinses with relation to polyamide and silk. The results showed statistically significant values ($P < 0.001$) for all the groups. HA rinse was at borderline with a mean tensile strength of 916 N/mm^2 and a group high of 960 N/mm^2 compared to the pre-immersion tensile strength reading at 1035.2 N/mm^2 for silk. Comparing the mean values of polyamide and silk, there was significant difference in tensile strengths at 289 N/mm2 and 458 N/mm2 respectively. This again was the value observed for silk. For polyamide suture material, the pre-immersion value was 354 N/mm^2 and the tensile strengths displayed for CHX and HA were 289 and 331 N/mm^2, respectively. The levels of significance were almost the same for CHX; however, for HA, the maximum mean had reached 351 N/mm^2 when compared to the pre-immersion value of 354 N/mm^2. The findings further strengthened the fact that irrespective of the suture material used, HA rinse had stabilized the tensile strengths of the suture materials after 24 h. CHX was not a significant contributor in maintaining tensile strength.

Discussion

This study evaluated the effect of commonly used CHX rinse along with HA rinse on nonabsorbable suture materials, silk and polyamide. The study aimed to see if significant changes were observed on the tensile strength of the tested suture materials, though studies on HA were carried out earlier to evaluate the bacterial accumulation on suture materials.[17,18] The rationale of using HA with mouth rinse CHX, as it is prescribed commonly by periodontist and oral surgeons post-surgery.[19,20]

In our study, the time frame was short when compared to similar studies on nonabsorbable suture materials, where the time frame was longer.[10] Silk was the only suture material used to evaluate tensile strength stability. The finding from our study was in accordance with a similar study, where silk showed similar drop in tensile strength when subjected to oral rinses and medicated gels.[16,20]

Polyamide being a monofilament suture and of synthetic nature can cause mucosal tears due to its cut ends. Tensile strength stability of polyamide in our study did not show a significant drop when placed in HA [Table 1], possibly due to the viscous nature of HA. It has the ability to bind polyamide more firmly, thereby lessening the solubility in thermo-standardized environments.[21] Though previous studies have commonly used nonabsorbable synthetic suture materials such as polyamide to assess tensile strength in comparison with other materials,[10] polyamide was not subjected to oral rinses in previous studies, it was subjected to a preset load under controlled machine guidance.

The tensile strength of polyamide after immersion had to be assessed in the current study, to evaluate if it is retained for a longer period. From the values obtained,

Table 1: Ethilon polyamide suture before and after immersion in hyaluronic acid and chlorhexidine

Solution	Period	Mean	Standard deviation	Changes	*P value
Chlorhexidine	Before	354.0	33.11	65%–18%	0.04 (S)
	After	289.0	32.28		
Hyaluronic acid	Before	354.0	33.11	23%–6.4%	0.08
	After	331.0	19.63		

S = significant

*$P \leq 0.05$, *Wilcoxon signed rank test

Table 2: Ethicon Mersilk suture before and after immersion in hyaluronic acid and chlorhexidine

Solutions	Period	Mean	Standard deviation	Changes	*P value
Chlorhexidine	Before	1035.2	67.49	577.2%–55.75%	0.001 (S)
	After	458.0	10.97		
Hyaluronic acid	Before	1035.2	67.49	119.2%–11.5%	0.008 (S)
	After	916.0	43.93		

S = very significant

*$P \leq 0.05$, *Wilcoxon signed rank test

Table 3: Intergroups comparison of groups—level of significance of chlorhexidine and hyaluronic acid with relation to polyamide and silk

Solutions	Suture	Mean	Standard deviation	Minimum	Maximum	*P value
Chlorhexidine	Ethilon polyamide	289.0	32.28	249.00	331.00	$P < 0.001$
	Ethicon Mersilk	458.0	10.97	444.00	474.00	
	Total	373.5	91.92	249.00	474.00	
Hyaluronic acid	Ethilon polyamide	331.0	19.63	300.00	351.00	$P < 0.001$
	Ethicon Mersilk	916.0	43.93	840.00	950.00	
	Total	623.5	309.98	300.00	950.00	

*Mann–Whitney *U* test

not much variations were observed when exposed to different media; the standard deviation was the least when placed in HA rinse at 19.63 N/mm^2 with a maximum tensile load observed at 351 N/mm^2, which was almost in tandem with the pre-immersion value of 354 N/mm^2 [Table 2].

Furthermore, it has been proved from the results of the study that polyamide would be a better option when selecting nonabsorbable suture material as silk causes more tissue reaction due to more tissue drag and has the ability to adhere to debris and bacteria.[17,22] Polyamide being a monofilament suture, has better handling characteristics, better bending capability, easier to knot, and does not produce the wicking effect.[18,23] HA-coated suture materials could offer superior physical properties as tensile strength stabilization to a certain degree as observed from this study [Table 3] and also could reduce bacterial growth as reported in an earlier study by Varma *et al.*[17] Use of HA and CHX in earlier studies did show characteristic differences in the accumulation of bacteria, but none of the earlier studies evaluated this aspect of HA when coated on suture materials.[23] The effect of HA on silk was also significant as little difference in the reduction of tensile strength was observed, and it was not substantial when compared with other rinses [Table 2], this factor was also in agreement with the finding of a study by Mohammed *et al.*,[19] in which tensile strength of silk had reduced significantly when placed in a herbal solution. This study was evaluated on a small time frame, this variable was also observed in a recent study where an herbal drug was loaded onto silk suture.[24] Though HA shows potential in stabilizing tensile strength when compared to other oral rinses, the exact mechanism in which this is carried out is not yet fully understood. More studies pertaining to textile physics and molecular technology could provide answers to this vital phenomenon.

Conclusion

It was concluded that between the two nonabsorbable suture materials, polyamide showed better stability compared to silk. Among the media used to evaluate the role of tensile strength stability, HA showed promising results as it did not have any effect on the tensile strength of both suture materials. Well-planned clinical studies are required to investigate the results of this *in vitro* study.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

S.R.V and M.J was involved in Concepts, Design, Statistical Analysis, Manuscript Editing and preparation. S.A.F and V.D was involved in Design and Manuscript Editing and preparation. A.M and S.N was involved in Manuscript Editing and preparation.

Ethical consent and institutional review board statement

The protocol for this experiment has been registered in protocols.io, (dx.doi.org/10.17504/protocols.io.2f2gbqe). As the study followed an *in vitro* environment, it was granted an exemption in writing by the Deanship of Graduate Studies and Research, College Research Committee, Ref. No.: UGD-L-18-12-19-34.

Patients declaration of consent

Not Applicable as Invitro Study.

Data availability statement

The study Methodology and results are made available in protocols.io,(dx.doi.org/10.17504/protocols.io.2f2gbqe).

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