Original Article

In Vitro Study of Tensile Strength Comparison of Selected Nonabsorbable and Absorbable Suture Materials after Immersion in 0.12% Chlorhexidine Gluconate

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Abstract

Aim: To compare the tensile strength (TS) of absorbable and nonabsorbable suture materials after immersion in 0.12% chlorhexidine gluconate. **Materials and Methods:** Six 4-0-gauge suture materials were used, namely silk (S), polypropylene (PP), polyamide 6 (PA6), polyglactin 910 (PG910), poliglecaprone 25 (PL25), and polydioxanone (PDX). A total of 540 suture materials were divided equally (90) into six groups and tested. These materials were divided into a nonimmersed condition (10) and two thermostatically controlled immersion media (40 each), using artificial saliva for the control group (CG) and 0.12% chlorhexidine gluconate for the test group (TG). The specimens were tied to prefabricated rubber rods before immersion and removed at the testing timepoint. By using a universal testing machine (Instron 5566) with hooks attached, a hook-mounted specimen TS testing was performed on days 0, 1, 3, 7, and 14 at a 10 mm/min crosshead speed until the material was stretched to failure, and the maximum TS was recorded in Newtons (N). The continuous variables were taken as the mean and standard deviation across the six study groups to assess the significance at $\alpha = 0.05$. A two-factor analysis of variance (ANOVA) was performed to assess the TSs over time in different media. A Bonferroni correction was performed when the data were statistically significant according to a two-factor ANOVA. Intragroup statistical comparisons were performed by repeated ANOVA for each study group. All data were analyzed using SPSS 26. **Results:** The suture material TS analysis showed that nonabsorbable suture materials maintained their TS throughout the study; silk exhibited different behaviors, decreasing in TS from baseline to day 1 and maintaining its TS until day 14. All absorbable suture materials decreased in TSs by day 14. The silk and PG910 samples in the TG performed significantly better than those in the CG. **Conclusions:** Prescribing 0.12% chlorhexidine gluconate as a postsurgical mouth rinse is safest when silk and PG910 are the optimal suture materials.

Keywords: *0.12% chlorhexidine gluconate, absorbable, nonabsorbable, sutures, tensile strength*

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Introduction

Wound healing is a complex process with several interconnected phases and is affected by different factors.[1] There are three types of intentional wound healing: Primary, secondary, and tertiary intention healing. In primary intention healing, tissues are returned to their normal anatomic structures with the same tissue structure they had before the injury.[2-5] With this technique, sutures are predominantly utilized since they are used to reapproximate the wound edges together. Therefore, sutures are key for ensuring proper wound healing and stability in clinical behavior over a certain period, particularly in the field of dentistry.[6] However, suturing inside the mouth is not the same as suturing in other areas of the body for various reasons, such as the type and vascularization of tissues, the constantly wet environment with saliva, and the functions of the region, such as speaking, chewing, and deglutition. Thus, every dentist must comprehensively understand the different biomechanical properties of suture materials.[7] Among these biomechanical properties, tensile strength (TS) is a crucial mechanical characteristic that indicates the ability of a suture material to resist stress during knotting.[8] Furthermore, the resorption rate of absorbable suture materials can also be a significant factor influencing their TS.[9]

Sutures can be classified into different groups: Synthetic or natural, absorbable or nonabsorbable, and monofilament or multifilament.[10] Absorbable sutures used in the mouth include poliglecaprone 25, which is a monofilament synthetic fiber, and polyglactin 910, which is a braided multifilament synthetic fiber.[9] Another absorbable suture is polydioxanone, which is an absorbable synthetic monofilament characterized by optimal maneuverability and reduced bacterial adhesion.[7] For the nonabsorbable suture group, silk is the most routinely used nonabsorbable natural suture material due to its superior handling characteristics.[11] Polyamide is a monofilament synthetic suture utilized in oral surgery because it exhibits lower knot tie-down resistance, less tissue drag, and less stiff resistance than silk.[12] Polypropylene is a monofilament synthetic suture material that demonstrates minimal tissue reactivity and high durability, and it retains its TS over a wide range of pH values.[13]

Chlorhexidine gluconate is a gluconate salt and a biguanide compound that has been in clinical use for over 60 years.[14] During the COVID-19 pandemic, several authors[15-17] concluded that chlorhexidine gluconate, particularly at a concentration of 0.12%, can be favorable for controlling the spread of SARS-CoV-2 droplets, thereby preventing the spread of infection. Conversely, in most follow-up treatments for dental surgeries, mouth rinses, such as chlorhexidine, are often recommended.[18] Moreover, the selection of mouthwashes is based on the frequent prescription of chemotherapeutic agents that control plaque formation.[19] Some authors[10,18] have also mentioned that certain mouth rinses, such as chlorhexidine, can affect the properties of suture materials, particularly TS.

Therefore, the aim of this study was to compare the TSs of absorbable and nonabsorbable suture materials after immersion in 0.12% chlorhexidine gluconate.

Materials and Methods

Study design

The investigators conducted an analytical laboratory (*in vitro*) study to compare the TS of absorbable suture materials, including polyglactin 910 (PG910), poliglecaprone 25 (PL25), and polydioxanone (PDX), and nonabsorbable suture materials, including silk (S), polypropylene (PP), and polyamide 6 (PA6), after immersion in 0.12% chlorhexidine gluconate from June to August 2022. All the sutures were 4-0 gauge and procured from Ethicon Inc, Somerville, NJ, USA, Inc. A total of 540 suture samples were used in the study.

Sample size calculation

The sample of interest was 540, and the confidence interval was 95%. The margin of error was set at 15%. The formula[20] used for the computation of sample size is seen in Figure 1. The initial computation of n yielded 341.5. However, based on previous studies, a maximum of 10 and a minimum of 5 suture samples per suture type and time period were used. Therefore, it was decided to increase the sample size to 540 to accommodate 10 suture samples per suture type, immersion medium, and period.

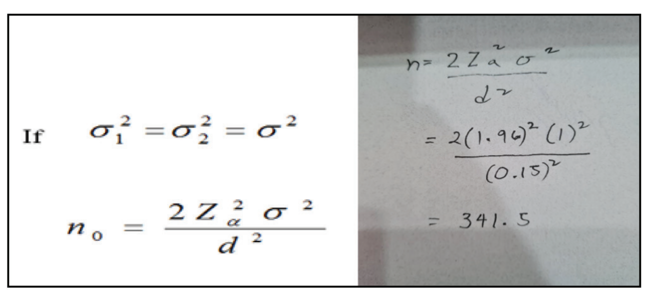

Figure 1: Sample size calculation

Research tool

The study involved the use of a universal testing machine (Instron 5566, Instron Ltd., Buckinghamshire, England) with external metal hooks attached to the clamps. The crosshead speed was set at 10 mm/min. The samples were mounted on hooks with the knot positioned at the midpoint and then stretched to failure [Figure 2]. The machine was connected to a computer for digital output that measured the TS, and the maximum TS was recorded in Newtons (N).

Sample distribution

The 540 suture samples were divided equally (90 samples) into six groups according to type. The samples were further divided into nonimmersed conditions (10 samples) and two thermostatically controlled immersion media (40 samples each); artificial saliva was used for the control group (CG), and 0.12% chlorhexidine gluconate was used for the test group (TG). Testing was performed on days 0 (nonimmersed specimens), 1, 3, 7, and 14. Two out of the six types of suture materials were tested every 14 days to account for fatigue. Ten suture samples (nonimmersed) of each type were tested on day 0, while 20 suture samples of each type were tested on days 1, 3, 7, and 14; 10 suture samples were tested in the TG, and another 10 suture samples were tested in the CG. Therefore, a total of 40 suture samples were tested on days 1, 3, 7, and 14, while a total of 20 suture samples were tested on day 0. Only 10 suture samples per suture type were used in the nonimmersed condition; thus, there was an equal distribution of the samples throughout the study, thereby fulfilling the 10 suture samples per suture type, immersion medium, and period. All of the tests were performed by one investigator only.

Figure 2: Mounted suture sample with metal hooks on the Universal Testing Machine

Rubber rods and suture specimens

Custom-made rubber rods made of cured polyvinylsiloxane material (DMG Silagum Impression Material) were used to hold the suture material in the study. The rubber rods were created by using a 3-cc syringe as a mold with a severed tip, facilitating unhindered removal of the cured material. On day 0, fifty-four rubber rods were made with uniform lengths and diameters of 50 mm and 9 mm, respectively. Ten suture samples were tied around a single rubber rod [Figure 3]. Each suture specimen was tied using knots that followed a 3:1:1 pattern. Eight rods with 10 suture specimens remaining in tension were set in a sterile glass container labeled with the experimental condition name [Figure 4]. During the testing day, 10 specimens were carefully removed from the rubber rod using College forceps, whereas the remaining specimens were left untouched to be tested on subsequent days.

Immersion media

The media included artificial saliva, which was used for the CG, and 0.12% chlorhexidine gluconate, which was used for the TG. Since this was an *in vitro* study, the saliva simulation was based on these previous studies.[10,21,22] However, due to the availability of chemical components, the preparation of the artificial saliva was modified based on the study by Kurihara *et al*.[23] by mixing 2.2365 g of KCl, 0.5443 g of KH_2PO_4, 0.0776 g of $CaCl_2.2H_2O$, 0.019 g of $MgCl_2$, and 4.7662 g of 4-(2-hydroxyethyl)-piperazineethanesulfonic acid HEPES ($C_6H_{18}N_2O_4S$) mixed with 1 liter of distilled H_2O. The artificial saliva was made within 24 h and autoclaved before day 0 of the study on the same floor

Figure 3: Rubber rod with suture sample preparation

Figure 4: Experimental conditions

where the universal testing machine was located. Both media were kept in the dark until the execution of the experiment. Both media were prepared and maintained at a standard pH of 7.4 throughout the experimental period; the pH was measured by a laboratory pH meter, and the media were stored in an incubator at 37°C during the testing period. All the test media were changed every two days, with the rubber rods removed from the container and rinsed with 0.9% normal sterile saline for the duration of the study.

Statistical analysis

Normality was tested using the Kolmogorov–Smirnov test. The continuous variables are presented herein as the means and standard deviations across the 6 study groups, with significance assessed at $\alpha = 0.05$. A two-way analysis of variance (ANOVA) was performed to assess TS concentrations over time and in different media. Bonferroni correction was performed when the data were statistically significant according to a two-factor ANOVA. Intragroup statistical comparisons were performed by repeatedly conducting an ANOVA for each study group. Multiple comparisons between suture materials were assessed using the Bonferroni method. The data were analyzed using Statistical Product and Service Solutions (SPSS) 26.

Results

All the suture samples exhibited varying TSs at baseline [Table 1], with the mean TS of the PL25 exhibiting the highest value and that of S exhibiting the lowest value. The TS values of the nonabsorbable suture materials were maintained from day 1 to day 14, and the TS values were significantly different between the two experimental groups [Figures 5 and 6]. In contrast, the absorbable suture materials demonstrated significantly variable TS values, mostly trending toward reduced values. Notably, all the absorbable suture materials had significantly greater TS values at baseline than did the nonabsorbable suture materials, but all the absorbable suture materials had the lowest TS values by day 14, except for PG910.

The data were normally distributed. The interaction between the experimental groups and time points was not statistically significant for S ($P = 0.337$), PP ($P = 0.371$), PA6 ($P = 0.463$), PG910 ($P = 0.159$), or PDX ($P = 0.293$), but it was statistically significant for PL25 ($P = 0.002$). Next, the intragroup comparison of TS was analyzed in each experimental group. There was a statistically significant difference at the 0.05 level for the CG TSs for S ($P = 0.016$), PG910 ($P = 0.003$), PL25 ($P < 0.001$), and PDX ($P < 0.001$), and for the TG TSs

Table 1: Pre-Immersion values of tensile strength measured in Newtons (N)

Suture	Silk	Polypropylene	Polyamide 6	Polyglactin 910	Poliglecaprone 25	Polydioxanone	P-value
Pre-immersion/Baseline Values (Day 0)	16.33 (0.90)	23.93 (1.58)	19.15 (1.35)	28.37 (1.56)	31.74 (3.95)	27.86 (1.84)	<0.001

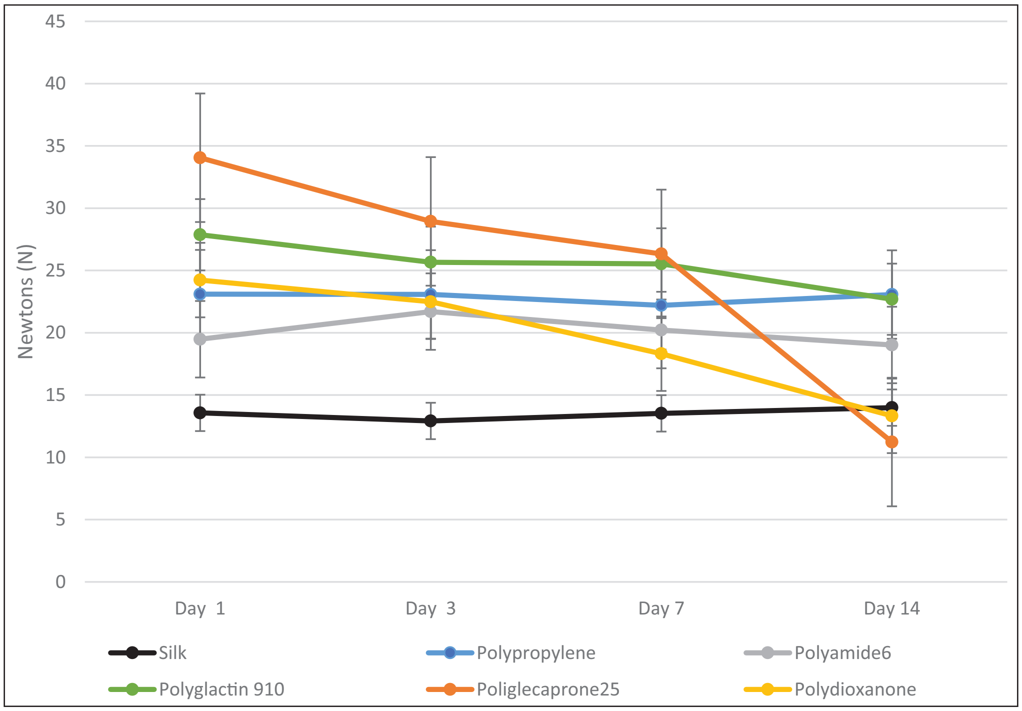

Figure 5: Comparison of the tensile strength of different suture materials immersed in artificial saliva

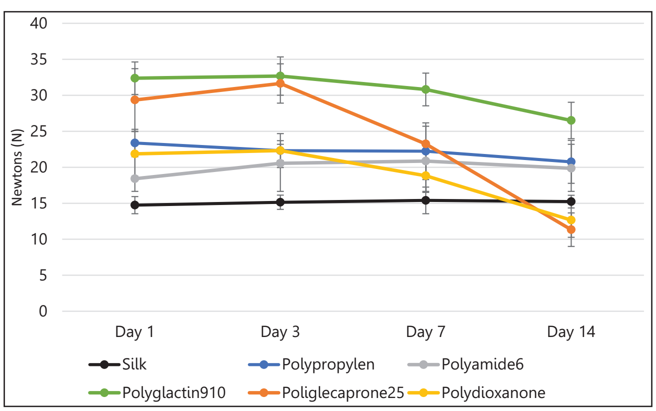

Figure 6: Comparison of the tensile strength of different suture materials immersed in 0.12% chlorhexidine gluconate

for PG910 ($P = 0.004$), PL25 ($P < 0.001$), and PDX ($P = 0.001$) at each time point. No statistically significant differences were detected for the CG or TG of PP ($P = 0.929$ and $P = 0.392$) or PA6 ($P = 0.126$ and $P = 0.257$) as well as the TG of S ($P = 0.599$) [Table 2].

Subsequently, an intergroup comparison of the TS was performed. The mean TS of the TG was higher than that of the CG on days 3, 7, and 14 for S and days 1, 3, 7, and 14 for PG910, which was statistically significant at the 0.05 level. There was no statistically significant difference between the mean TSs of the CG and TG on days 1, 3, 7, and 14 for PP and PA6 ($P > 0.05$). The TS concentration in the TG was significantly lower than that in the CG on days 1 and 7 for the PL25 cohort and day 1 for the PDX, which was statistically significant at the 0.05 level [Table 2].

Discussion

On March 12, 2020, the World Health Organization declared COVID-19 a pandemic. Protocols were aimed at reducing patient encounters to decrease exposure time to the virus, given the nature of work in oral and maxillofacial surgery settings where different suture materials are always used.[24] This fact leads us to the importance of the TS of sutures. As previously mentioned, sutures play the most important role in ensuring that a wound heals properly; ideally, TS losses occur while the wound gains strength. Thus, it is imperative that suture materials maintain their TSs to avoid interrupting proper reapproximation of the

Table 2: Tensile strength of suture materials in Newtons (N) immersed in artificial saliva (Control Group) and 0.12% chlorhexidine gluconate (Test Group) on Day 1, Day 3, Day 7, and Day 14

	Time	Artificial saliva (mean ± SD)	0.12% Chlorhexidine gluconate (mean ±SD)	*P* value[a]
Silk	Day 1	13.57±1.41	14.74±1.19	0.057
	Day 3	12.92±0.97	15.14±0.99	0.002*
	Day 7	13.53±1.66	15.40±1.85	0.003*
	Day 14	13.99±1.21	15.23±0.88	0.003*
	P value[b]	0.016*	0.599	
	P value[c]	0.337		
Polypropylene	Day 1	23.10±2.53	23.37±1.90	0.811
	Day 3	23.08±1.70	22.31±1.39	0.202
	Day 7	22.20±3.55	22.23±3.94	0.984
	Day 14	23.07±2.67	20.75±2.98	0.159
	P value[b]	0.929	0.392	
	P value[c]	0.371		
Polyamide 6	Day 1	19.48±3.07	18.41±2.95	0.219
	Day 3	21.70±2.24	20.55±2.45	0.402
	Day 7	20.22±2.03	20.86±2.04	0.584
	Day 14	19.02±2.19	19.86±1.37	0.346
	P value[b]	0.126	0.257	
	P value[c]	0.463		
Polyglactin 910	Day 1	27.87±2.86	32.37±2.26	0.009*
	Day 3	25.66±0.76	32.67±2.66	<0.001*
	Day 7	25.53±1.58	30.81±2.27	<0.001*
	Day 14	22.69±1.42	26.50±2.53	0.002*
	P value[b]	0.003*	0.004*	
	P value[c]	0.159		
Poliglecaprone 25	Day 1	34.05±5.16	29.35±4.35	0.045*
	Day 3	28.94±3.57	31.64±2.73	0.103
	Day 7	26.33±1.62	23.24±2.46	0.008*
	Day 14	11.23±2.22	11.33±2.33	0.928
	P value[b]	<0.001*	<0.001*	
	P value[c]	0.002*		
Polydioxanone	Day 1	24.23±1.95	21.86±3.10	0.026*
	Day 3	22.49±2.96	22.32±2.36	0.857
	Day 7	18.32±2.99	18.83±2.32	0.731
	Day 14	13.33±2.25	12.66±2.39	0.515
	P value[b]	<0.001*	0.001*	
	P value[c]	0.293		

P-value: [a]inter-group comparison, [b]intra-group comparison, and [c]interaction between group, *time

*Statistically significant at the 0.05 level (α = 0.05)

wound during healing. Moreover, oral rinses, such as 0.12% chlorhexidine gluconate, have gained popularity and importance in their usage as presurgical and postsurgical rinses. Therefore, it is of utmost importance to discuss the effect of chlorhexidine gluconate on the TSs of suture materials.

The results revealed varying TS values after immersion in 0.12% chlorhexidine gluconate, indicating that some of the sutures were positively affected, some were negatively affected, and some were unaffected. We can explain this phenomenon well by reviewing each type of suture material individually, comparing the TSs between the experimental groups, and analyzing certain factors, such as suture structure, behavior, and application.

The immersed silk in the TG had significantly better performance than the silk in the CG. Silk is a nonabsorbable multifilament natural suture material that is susceptible to loss of TS in the presence of moisture.[25,26] Therefore, it is evident that the decrease in TS from the baseline is caused by its exposure to a wet environment, but the mean TS shows consistent values until day 14. These results are consistent with these findings,[22] wherein it has been demonstrated that silk maintains its strength throughout a period; the performance of silk in commercial rinses does not differ from that of artificial saliva, while other authors[26-28] have shown that the mean TS values from baseline values to those of silk immersed in artificial saliva are very similar to those in the present study.

Polypropylene exhibited consistent performance in both the CG and TG. Hence, the TS of PP is maintained for long periods.[29] As a nonabsorbable monofilament synthetic suture, knot slippage occurs frequently on day 14 when immersed in the TG. This phenomenon can be validated by observing the graph while measuring the TS specifically at the final point of extension (8–10 mm), where we find a final intermittent decrease in the TS. Several authors[26,28,30] have observed different findings since their results show that there is a significant reduction in the TS of PP.

The performance of PA6 was very consistent in both the CG and TG, with a very slight increase in the mean TS observed from baseline compared to day 14 in the TG. The reason for this slight increase is that PA6, a monofilament synthetic nonabsorbable suture material, is found to have memory.[31] The memory of PA6 begins when it is still unknotted. According to the mean TS values, the memory of the knot was established immediately on day 1 and then peaked on day 3 in the CG, but it continually decreased until day 14. Moreover, the memory of the knot was established on day 3 and peaked on day 7 in the TG but decreased on day 14, which was still slightly greater than the baseline mean TS values. The decrease in the mean TS value can be attributed to knot slippage.[10] Hence, the memory of the knot of the polyamide was knotted, which peaked on day 7 in the TG but was still present on day 14. However, statistical analysis revealed that there was no statistically significant difference in the mean TS value of PA6 between the intragroup and intergroup comparisons. Therefore, PA6, which is similar to PP, has a more constant mean TS relative to the graphs measuring TS, even though PP has a higher overall TS value. This phenomenon was confirmed by Gonzales-Barnadas *et al*.[32] It has been stated that monofilament polyamides are elastic and withstand high tensile forces and traction. Varma *et al*.[18] concluded that polyamide had better stability than silk.

The PG910 score continually decreased across all-time points in the CG, but this increase was evident until day 3 in the TG. Interestingly, the mean TSs at days 1, 3, and 7 in the TG were significantly greater than the baseline values. Moreover, the mean TS values also increased from baseline values until day 3. PG910 is an absorbable multifilament synthetic suture material that is susceptible to hydrolytic degradation.[10] The increase in mean TS values could be due to the observed rigidity of PG910 during handling, which shows that it has memory as well. The baseline values were consistent with the memory of PG910 when it was still unknotted. Then, according to the mean TS values, the memory of the knot was immediately established on day 1, and a better interlocking of the filaments of the PG910 could have contributed to this as well. On the other hand, hydrolytic degradation can also explain the gradual decrease in TS concentration from day 1 to day 14. However, the significantly higher mean tensile values, as previously mentioned, may also be attributed to 0.12% chlorhexidine gluconate having a less intense hydrolytic degradation effect than artificial saliva on PG910. Therefore, molecular analysis of the interaction between PG910 and two of the immersion media should be performed in future studies to validate the results of the present study. These results are related to the findings of Ferguson *et al*.[33] and Alsarhan *et al*.,[10] where a gain in strength was apparent on day 7 in the latter study in artificial saliva and 0.12% chlorhexidine gluconate; on day 4, in the former study, a gain in strength was apparent in artificial saliva, and the specimen decreased in strength thereafter. These results contrast with those of the studies by Alshehri *et al*.,[22] Alamer *et al*.,[30] and Abullais *et al*.[34] in which maintenance or very little decrease in TS was evident among all-time points in artificial saliva and in the Curasept mouthwash used by Alshehri *et al*.[22] Contrasting results have been observed in various other studies;[28,35,36] however, there is a noticeable decrease in TS at all-time points in artificial saliva. These varying results can be attributed to the use of different formulations of artificial saliva. Interestingly, the TSs of PG910 and S are very similar since both are multifilament suture materials. However, S has an advantage over PG910 in terms of maintaining the TS, even though PG910 has a significantly high overall TS.

The performance of PL25 was erratic according to the differences between the CG and TG. This finding is attributed to the fact that monofilament suture materials are reported to have memory.[31] For the baseline values, which showed the largest standard deviation among the suture materials, the memory of PL25 began when it was unknotted since the test was conducted immediately after knot tying. The memory of the knot was established on day 1 for the CG and on day 3 for the TG. However, due to hydrolytic degradation and knot slippage,[10] TSs were continuously lost from day 3 to day 14 in both groups. However, the results of Alsarhan *et al*.[10] are quite different from the results of this study, wherein a continuous decrease in TS was observed at all-time points. Notably, an increase in TS was observed on day 7 by Taysi *et al*.[28]

PDX exhibited a continuous decrease in TS at all-time points. PDX is an absorbable monofilament synthetic suture material that is susceptible to hydrolytic degradation, explaining the decrease in TS. PDX exhibited considerably less knot slippage than did PL25, as shown by the consistent decrease in TS. Conversely, when comparing both experimental groups, the performance of this suture material was significantly better in the CG than in the TG. However, throughout their study, Taysi *et al*.[28] maintained the TS of PDX, which exhibited the highest TS among the six tested suture materials. Such differences in values may have occurred due to the different brands being used and the various formulations of artificial saliva.

It is also of prime concern to discuss the significant differences in TS between the nonabsorbable and absorbable suture material groups. The results of this study revealed that the overall TS of all the absorbable suture materials was significantly greater than that of the nonabsorbable suture materials, which is similar to the findings of Taysi *et al*.[28] However, nonabsorbable suture materials generally have more consistent TSs at different time points than absorbable suture materials. In the study by Abullais *et al*.[26] and Alamer *et al*.,[30] TS of the nonabsorbable suture material PP was greater than that of the absorbable suture material PG910. This finding is dissimilar to the results of this study. The two previously mentioned studies stated that the suture materials used were manufactured in India, while the suture materials used in this study were manufactured in the USA and China. In addition, Taysi *et al*.[28] reported contrasting results. In their study, PDX had the highest TS, followed by PL25, PP, and PG910, with PP having a slightly greater TS than PG910. The PG910 and PL25 suture materials with a brand of Ethicon were reportedly manufactured in the USA, while the other suture materials had different brands. Even though the brand name used in this study coincided with the same brand used in another study, the place where the suture materials were manufactured must be considered. Ethicon has various manufacturing sites, as previously mentioned, that have environmental differences in temperature and humidity. Another reason for the different TS values is the method of mounting the suture material on the testing machine.

Importantly, the results of this study can be used to a certain degree in the clinical setting. For a generally clinically healthy patient who undergoes routine oral surgical procedures, such as removing impacted third molars, any of the six suture materials tested can be recommended for use; these materials perform well on days 1 and 3 since these times are when peak swelling occurs. However, if the surgery duration is long, the amount of postoperative swelling is expected to subside for a relatively long time.[37] Therefore, sutures that have a high TS that is adequately maintained, such as PP, PA6, and PG910 sutures, must be used. Furthermore, oral surgical procedures, such as those in which guided bone regeneration is used, necessitate suture removal after 12–15 days; these procedures can make use of the sutures previously mentioned.[38] Conversely, it is recommended that nonabsorbable suture materials, especially PP and PA6, be used in patients who experience delayed wound healing, such as those who have diabetes mellitus, those who exhibit thyroid dysfunction, or those who are receiving immunosuppressive therapy.[3,39] Thus, when there is knowledge of how long it takes for a suture material to exhibit adequate TS in relation to wound healing, the oral surgeon can estimate how long the suture material needs to stay in place in various other oral surgical procedures, such as preprosthetic and dental implant surgeries.

Another important clinical factor that needs to be discussed is the increased risk of infection due to the physical characteristics of the suture materials. According to these studies,[40,41] any suture material can cause bacterial biofilm accumulation, but not all suture materials have the same amount of accumulation present. In addition, the formation of biofilms is dependent on the type of suture material. As a result, these suture materials can have adverse effects on wound healing. To minimize infection, 0.12% chlorhexidine gluconate was selected as the immersion media for the TG based on the frequent prescription of chemotherapeutic agents that control plaque formation.[19]

This study has several limitations. This research focused only on specific types and manufacturing sites of suture materials, the reasons for which have been previously mentioned. Another limitation was the composition of artificial saliva; the investigators were limited to the chemical components present at the study site. In addition, only one mouthwash served as the test condition. Like all other *in vitro* studies conducted, this study could not fully reproduce what occurs inside the oral cavity; thus, the results should be interpreted with caution.

Conclusion

Chlorhexidine gluconate (0.12%) has a significant positive effect on multifilament suture materials (S and PG910) regardless of whether they are absorbable or nonabsorbable; however, chlorhexidine gluconate has a significant negative effect on the PDX. Conversely, it has no significant effect on PA6, PL25, or PP. Therefore, it is safest to prescribe 0.12% chlorhexidine gluconate when S and PG910 are the chosen suture materials. It is recommended that a similar study be performed *in vivo* to simulate the environment of the oral cavity properly and accurately. It is also recommended to test other mouthwashes, such as povidone iodine, Listerine, and herbal rinses, which are commercially available.

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Conflicts of interest

The authors declare that they have no conflicts of interest or competing interests.

Author contributions

E.C.: *In vitro* study, data acquisition, statistical analysis, manuscript preparation, manuscript editing, and literature research; T.C.: Data acquisition, definition of intellectual content, manuscript review, and literature research; C.V.: Study concept, study design, definition of intellectual content, statistical analysis, manuscript review, and manuscript editing. All authors reviewed the manuscript.

Ethical Policy and Institutional Review Board Statement

All procedures performed in this study did not involve human or animal participants.

Patient Declaration of Consent

Not applicable

Data Availability Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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