Original Article

Evaluation of Tensile Strength of Surgical Absorbable and Non-Absorbable Suture Materials-An *In vitro* Study

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ABSTRACT

Background and Objective: The aim of the study was to evaluate the tensile strength of surgical Absorbable and Non-absorbable suture materials.

Material and Methods: A total of 360 samples of absorbable and non absorbable suture materials were tested for tensile strength in a simulated oral environment using INSTRON machine on 1st, 7th and 14th day. Absorbable suture materials catgut (Trugut), polyglycolic acid (Truglyde), polydioxanone (PD Synth), and non-absorbable sutures, silk (Trusilk), polyester (Trubond), polyproplene (Trulene) of three different dimensions (3-0, 4-0, 5-0 respectively) were used. Repeated measure by ANOVA and Man Whiney U test were used to compare the degradation of tensile strength.

Results: Among absorbable sutures, Catgut 5-0 showed maximum deterioration of tensile strength ($p<0.043$) and polyglycolic acid 3-0 showed minimum deterioration ($p< 0.05$) whereas among non-absorbable sutures Silk 4-0 showed maximum deterioration of tensile strength ($p< 0.005$) and Polypropylene 3-0 showed minimum deterioration ($p<0.041$).

Conclusion: In this study, polyglycolic acid (Truglyde) 3-0 (absorbable sutures) and polyproplene (Trulene) (non-absorbable suture) 3-0 will be the preferred material for the periodontal surgeries where sutures need to be retained for longer periods. Catgut (Trugut) 5-0 (absorbable sutures) and silk (Trusilk) 4-0 (non-absorbable sutures) can be used in minor surgical procedures since there is significant deterioration in tensile strength in 7 days.

Keywords:
Suture materials, Wet mouth, absorbable suture materials, non-absorbable suture materials, tensile strength, Instron universal testing machine

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INTRODUCTION

Suture material is a biomaterial device used to ligate blood vessels or approximate tissues. [1, 2, 3] Tensile strength is the measure of time for suture material to lose 70-80% of its initial strength. Khiste *et al* evaluated tensile strength of synthetic absorbable suture materials namely polyglycolic acid (PGA), polyglactin (PG 910), and poly (glycolide-co-ε-caprolactone) (PGC) under simulated oral conditions and concluded that polyglycolic acid has greater tensile strength. [1]As there are only few studies comparing absorbable and non absorbable sutures in simulated oral environment this study has been taken up to evaluate their tensile strength.

The aim of the study was to evaluate the tensile strength of surgical absorbable and non-absorbable suture materials and to compare their deterioration of tensile strength on first, seventh and fourteenth day.

MATERIAL AND METHODS

A total of 360 (60 samples for 6 sutures) samples with six types of surgical absorbable and non-absorbable suture materials were tested. Absorbable suture materials such as catgut (Trugut), polyglycolic acid (Truglyde),

polydioxanone (Pd Synth) (Sutures India, Peenya industrial area, Bengaluru, Karnataka), and non absorbable materials such as black silk suture (Trusilk), polyester (Truebond), polyproplene (Trulene) (Sutures India, Peenya industrial area, Bengaluru, Karnataka),were tested. Three gauges namely 3-0, 4-0 and 5-0 of each type were used. Five samples per gauge were chosen to perform the study. Each suture material was cut into five equal lengths of about 100 mm and were attached to acrylic blocks made with 8 mm length and 6 mm breadth (Figure 1). They were placed to the arms of Instron Universal Testing Machine. Five samples of each suture material have been tested in dry and wet environment after 1st, 7th and 14th day by moving the head of the machine at the rate of 25cm/min. The evaluation of tensile strength is performed both in dry and wet environment. Base line value of tensile strength was obtained by evaluating the tensile strength in the dry environment. Nine ml of artificial saliva (Wet Mouth) in each beaker was used for the simulation of the oral environment. First day post immersion, seventh day and fourteenth day post immersion evaluation of tensile strength was performed using the Instron Mechanical testing device.1

Twenty samples each of three gauges 3-0, 4-0 and 5-0 of Catgut(Trugut), polyglycolic acid (Truglyde), polydioxanone (Pd Synth), black silk suture (Trusilk), polyester (Truebond) and polyproplene (Trulene) were subjected to Instron Mechanical Testing Device to get the tensile strength baseline values. Same numbers of samples of all suture materials were immersed in a tumbler of artificial saliva (Figure 2) to evaluate the tensile strength on first day, seventh day and fourteenth day. From each tumbler five samples of each suture materials of three dimensions were taken on first day, seventh day and fourteenth day and attached to the arms of the Instron Universal testing device to evaluate the tensile strength (Figure 3). Each material was stretched to get the point of breakage and the values were collected.

Figure 1 : Sutures attached to acrylic blocks.

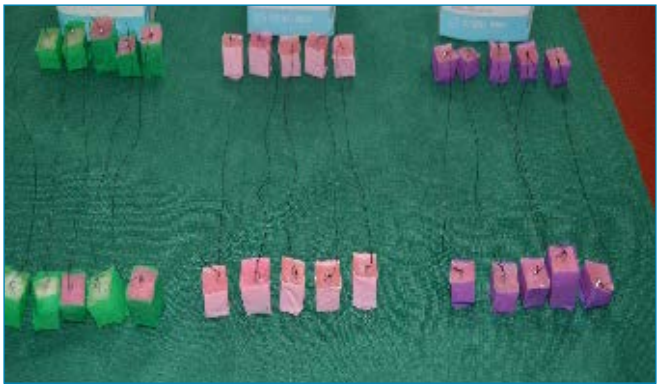
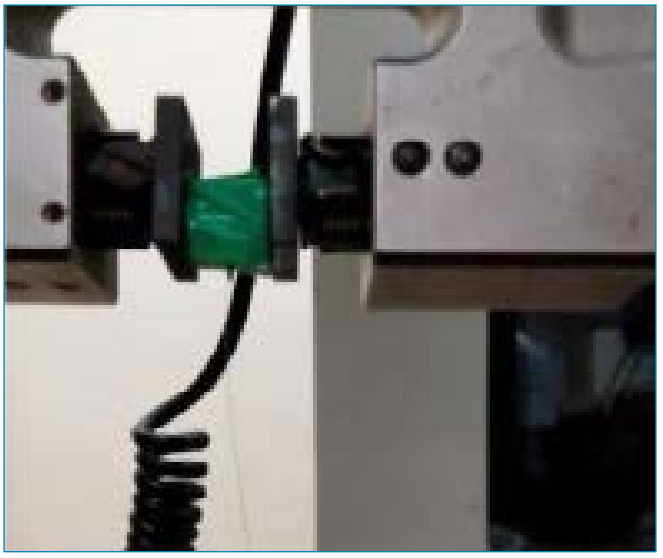


Figure 2 : Sutures placed in artificial Saliva.

Figure 3: Moveable arm Instron Machine.



RESULTS

Suture materials kept in normal conditions and in artificial saliva were compared statistically using values of tensile strength in Newtons. All suture material loops were intact at the end of their respective soaking periods and were suitable for mechanical testing. Each suture materials demonstrated an obvious breaking point during mechanical testing on the Universal Ultra test machine.

Absorbable Sutures

The deterioration of tensile strength of absorbable suture materials within a stipulated time period of 14 days is as follows, catgut 5-0 (Trugut) showed maximum deterioration of tensile strength from 8.06 N to 3.174 N and (Truglyde) polyglycolic acid 3-0 showed minimum deterioration of tensile strength from baseline value of 26.9 N to 24.65 N.

When comparing three dimensions 3-0, 4-0, 5-0 among absorbable sutures, polyglycolic acid had minimum deterioration and catgut had maximum deterioration of tensile strength. The tensile strength of other absorbable suture materials are tabulated in Table 1.

Non-Absorbable Sutures

The deterioration of tensile strength of Non-absorbable suture materials within a stipulated time period of 14 days is as follows, silk 4-0 (Trusilk) showed maximum deterioration of tensile strength from base line value of 10.3 N to 7.172 N and Polypropylene 3-0 (Trulene) showed minimum deterioration of tensile strength from its baseline value of 18.42 N to 16.95 N.

When comparing three dimensions 3-0, 4-0, 5-0 among non-absorbable sutures, polypropylene 3-0 and 4-0 showed minimum deterioration of tensile strength and polyester 5-0 showed minimum deterioration of tensile strength, whereas silk 3-0, 4-0, 5-0 showed maximum deterioration. The tensile strength of other non-absorbable suture materials are tabulated in Table 2.

Table 1: Mean values of tensile strength (Newton) of the Absorbable suture materials, pre-immersion and post immersion from day 0 to day 14 in artificial saliva.

Materials	Dimensions	Pre-Immersion (Newton)	Post-immersion (Newton)		
		Day 0	Day 1	Day 7	Day 14
Catgut (Trugut)	3–0	21.2 ± 1.26	20.2 ± 1.27	16.2 ± 0.86	11.39 ± 0.94
	4–0	10.5 ± 0.97	9.0 ± 0.61	6.9 ± 0.52	5.268 ± 0.46
	5–0	8.0 ± 0.28	6.8 ± 1.34	5.8 ± 0.36	3.174 ± 0.08
Polyglycolic Acid (Truglyde)	3–0	26.9 ± 2.33	28.4 ± 1.24	0.25 ± 0.45	24.65 ± 0.86
	4–0	15.6 ± 0.4	15.5 ± 1.53	12.7 ± 0.84	11.69 ± 0.68
	5–0	8.6 ± 0.88	8.21± 0.54	8.1 ± 0.30	7.22 ± 0.20
Polydioxanone (Pd Synth)	3–0	22.3 ± 0.77	22.1 ± 0.72	19.6 ± 2.56	18.52 ± 0.64
	4–0	11.9 ± 0.76	10.8 ± 1.74	9.8 ± 0.68	6.62 ± 0.44
	5–0	9.1 ± 1.05	9.1 ± 0.59	8.6 ± 0.42	6.24 ± 0.41

Values are Mean ± SD

DISCUSSION

The present study compared deterioration of tensile strength among absorbable and non-absorbable (3-0, 4-0, 5-0) sutures. Synthetic absorbable and non-absorbable sutures share a single indication, providing temporary and mechanical support until natural tissue heals and regains strength. As the tissue heals, the degradable suture gradually weakens so that a gradual stress transfer occurs. The physical and mechanical properties of non-absorbable suture materials may vary when these materials interact with saliva and other body fluids; hence selection of absorbable and non-absorbable suture materials plays an important role to obtain proper wound healing. [1]

Several in-vitro studies are present in literature regarding tensile strength of suture materials but only few studies have been done in simulated oral environment. In the literature, very few studies had compared various dimensions of each suture materials tested.[1] In this study three dimensions of absorbable and non-absorbable suture materials were tested in simulated oral environment for a time period of 14 days and evaluated the tensile strength, which would help in the selection of suture materials in different clinical situations.

The medium for soaking suture materials in other in-vitro studies were soya, saline,milk.[4] In our study we selected artificial saliva (exactly mimicking natural

Table 2: Mean values of tensile strength(Newton) of the Non-absorbable suture materials,pre-immersion and post immersion from day 0 to day 14 in artificial saliva.

Materials	Dimensions	Pre-Immersion (Newton)	Post-immersion (Newton)		
		Day 0	Day 1	Day 7	Day 14
Silk (TruSilk)	**3–0**	17.2 ± 0.50	16.1 ± 0.22	14.4 ± 1.79	13.8 ± 0.55
	4–0	10.3 ± 0.91	10.2 ± 1.81	7.34 ± 0.50	7.17 ± 0.63
	5–0	7.4 ± 3.33	6.48 ± 0.59	6.06 ± 0.39	5.32 ± 0.19
Polyester (Truebond)	**3–0**	19.2 ± 2.14	19.0 ± 0.81	16.0 ± 0.64	16.0 ± 2.89
	4–0	14.4 ± 0.87	13.4 ± 1.19	11.6 ± 1.21	11.1 ± 0.71
	5–0	6.4 ± 0.95	6.3 ± 0.75	6.21 ± 0.64	5.78 ± 1.61
Polyproplene (Trulene)	**3–0**	18.4 ± 0.63	18.3 ± 0.27	17.4 ± 1.03	16.95 ± 0.75
	4–0	13.7 ± 0.68	12.6 ± 0.45	11.1 ± 2.52	10.98 ± 0.26
	5–0	7.74 ± 0.77	7.14 ± 1.0	6.67 ± 0.31	6.18 ± 1.22

Values are Mean ± SD

oral saliva) as a medium to evaluate the tensile strength. Although various combinations of saliva and serum have been reported in the literature[4] artificial saliva was used in this study to simulate the oral conditions.

Ferguson *et al* in his study reported reduced tensile strength of Vicryl when soaked in saliva compared to other liquids like soya, saline or milk.[5,6] Saliva enhanced the degradation of the sutures which results in the reduction in tensile strength. Alshehri *et al* also evaluated the tensile strength of silk, polyglactin, polytetrafluoroethylene in four medium and stated that there was reduction of tensile strength of these suture material by the interaction of salivary amylase enzyme and contents of immunoglobulin.[7] Also in Shahla Kakoei *et al* study, saliva was the medium to evaluate the tissue reaction of four suture material and concluded that saliva is the medium consists of abundant supply of bacterial species which invade through the suture material which can hinder the tissue healing,[7, 8] which is the very strong reason to use wet mouth to evaluate the tensile strength.

In this study, we used Instron Mechanical testing device as a tool to evaluate the tensile strength of suture materials like other studies.[9-11] Surgeons knot was used to attach the suture material to the acrylic block before subjecting it to test. Surgeons knot is recommended as a standard method to secure the knot. When using synthetic absorbable sutures, it is recommended that the surgeon's knot be used to prevent knot untying.[4] In this study the surgeon's knot was used for all samples and had maximum of two throws to prevent the untying.[12] The knot made with polyglycolic acid found to be more stable.[13,14]

In this study both absorbable and non-absorbable suture materials were evaluated in artificial saliva which had a pH value of 7.5. The pH of the medium is another important factor that gains more importance in the resorption of suture materials. Studies indicated that the pH levels were able to influence the performance of absorbable sutures more than non-absorbable suture.[15] Both acidic and alkaline environments are able to accelerate the degradation of natural absorbable sutures, while only alkaline conditions have this adverse effect on the synthetic or man-made absorbable sutures.

The next important parameter choosen was the duration of our study. The duration of our study and the selection of testing points at day 0, day 1, day 7 and day 14 were based on clinical relevance. The study was conducted for only 2 weeks because the sutures for most periodontal procedures are removed at that time.[4] The tensile strength of suture materials deteriorates over a period of time in oral environment. The suture

removal in periodontal surgeries is done between 7 and 14 days and hence the testing points were selected on day 1, 7 and 14.

We choose three absorbable and non absorbable suture materials of three different dimensions since they were not studied much earlier. Our study was unique in the sense that dimensions of 3-0, 4-0 and 5-0 of absorbable suture materials (catgut, polyglycolic acid, polydioxanone) and non-absorbable suture materials (silk, polyester and polypropylene) were used.

Among the three absorbable suture materials used in the study, the polyglycolic acid (PGA) 3-0 suture had the highest tensile strength in all dimensions at baseline. In the simulated oral environment, the PGA sutures maintained their tensile strength for the first 3 days but minimal reduction in the tensile strength was noted after day 3 till the day 14. However, in the study conducted by Moser *et al*[16] on using the Ringer's lactate solution, PGA showed no significant change in the strength for 0 to 13 days which were incubated at 37^0C.whereas in our study sutures were not incubated which may be considered as limitation of the study.[16] Thus temperature and type of solution could have had the effect on the tensile properties of sutures used.

Huang *et al*. in his study PGA was suggested to be the appropriate material for intraoral surgical procedures like microdebrider-assisted extended uvulopalatoplasty (MEUP) because it maintains high tensile strength till postoperative day seven.[12] The reason could be that since PGA is a monofilament suture, it can maintain its tensile strength better compared to other multifilament sutures.

In our study catgut showed maximum deterioration of tensile strength on day 14. Similar observation was noticed in Cassie *et al* study, where he observed the breaking tension of catgut and polyglycolic acid in stomach environment and found there was constant variation in tensile strength for catgut and polyglycolic acid.[17] The variation was more with polyglycolic acid as compared with catgut suture material, where the difference in result might be the change in medium as compared to this study. [17] In this study catgut suture material showed the least tensile strength. Similar studies by Muftuoglu *et al* evaluated the tensile strength of the catgut of size 4-0 using tension meter and found there was disintegration of tensile strength in the initial stage of the procedure, where the result of this study showed the same result. Rapid deterioration of tensile strength of suture material was detected in many other studies.[18] Mizuma *et al* evaluated the disintegration of catgut and concluded that the disintegration of tensile strength was noticed within 24-48 hrs which was similar in this study.[19]

The third suture material evaluated among absorbable suture material was polydioxanone. Its tensile strength (6.238N) was better than catgut (3.174N) and less than polyglycolic acid (7.22N) on fourteenth day.

Of the non-absorbable suture materials silk showed maximum deterioration in tensile strength, similar to the study conducted by Kim *et al* where they evaluated the tensile strength of silk which was subjected to the oral environment.[20] Mizuma *et al* evaluated the tensile strength of silk suture material in saline or canine serum, bile, activated or non-activated pancreatic juice and found there was least disintegration in its tensile strength of silk suture material which was not in accordance with this study, the difference might be the change in mediums used.[19]

Among the non-absorbable suture materials in the present study, polypropylene of 3-0, showed minimum deterioration in the tensile strength from18.4 N to16.95 N on day 14,which was similar to the study done by Postlethwait.[21] Karabulut *et al* in his study evaluated tensile strength of polypropylene suture material of size 5-0 both in-vitro and in-vivo conditions and concluded that among all other sutures, polypropylene suture material provided maximum stability in both in-vitro and in-vivo conditions.[3] Hence polypropelene had the lowest deterioration of tensile strength according to our study.

The third non absorbable material polyester of (5-0) dimension showed the maximum deterioration in tensile strength from 6.39 N to 5.778 N on day 14. Trail *et al* evaluated the tensile strength of different suture materials and found polyester had the least tensile strength supporting our study.[22] Vicente *et al* compared the structural properties of polyester suture materials and found there was more plaque accumulation in silk as compared to polyester suture material so the patients were having discomfort with silk suture than with polyester suture material.[23] Hence polyester would not be the ideal suture material where it had more tissue reaction and deterioration of tensile strength.

Previous investigations[9,11,24] of PGA sutures showed excellent handling properties, high initial

tensile strength, and less tissue reactions. The PGA suture possesses some properties superior to other materials like less tissue reaction and a greater tensile strength for similar diameters. It lasts longer than catgut, and disintegration can be precipitated since it is hydrophilic. It is easier to handle, easier to tie and does not produce stitch marks like those of silk or catgut.[17,25,26] All these findings showed PGA among absorbable sutures had the superior quality in tensile strength and tissue healing when compared to other suture materials.[24,27] In non-absorbable suture material polypropylene 3-0 showed minimum deterioration of tensile strength.

In clinical situations like flap surgeries, regeneration procedures, periodontal plastic surgeries, where the tissue will not regain their preoperative strength and with more tension exerted on surgical flaps, consideration should be given to use a suture material that can retain long term strength up to 14 days. Among absorbable suture materials, PGA 3-0 and non-absorbable suture material polypropylene 3-0 of least deterioration in tensile strength will be the preferred for the approximation of tissues for better healing. Among absorbable suture material catgut 5-0 (Trugut) and in non-absorbable suture materials silk 4-0 (Trusilk) showed maximum deterioration of tensile strength, hence it can be used in minor surgical procedures (including frenectomy, vestibuloplasty) where the suture material need to retain for one week.

CONFLICTS OF INTEREST

None

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