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ON INVESTIGATION OF TENSILE STRENGTH OF COMMERCIAL SYNTHETIC NON-ABSORBABLE SUTURE MADE FROM OF BLUE POLYPROPYLENE MONOFILAMENT

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ABSTRACT

Objective: The purpose of this research is to investigate the tensile strength of commercial synthetic non-absorbable suture made from blue polypropylene monofilament that commonly used in surgery.

Methods: The commercial synthetic non-absorbable made from blue polypropylene monofilament was prepared for this purpose. The ASTM C1557-03 was used as a standard the method for analysis. For accuracy of the measurement, the diameter of the sutures was measured using optical microscope. The tensile strength, strain at failure, and modulus elasticity of the sutures were measured following instruction from the standard test method. The graph strain versus stress was provided.

Results: Results show that that the average tensile strength of five valid tested samples is about 875.812 MPa. The average strain is found about 0.282. The average of modulus of elasticity is 4026.069 MPa.

Conclusion: It is concluded that the sutures of commercial synthetic non-absorbable suture made from blue polypropylene monofilament having linier elastic as well as plastic properties. The average tensile strength of five valid tested samples is about 875.812 MPa. The average strain at failure is found about 0.282. The average of modulus of elasticity is 4026.069 MPa.

Keyword: Tensile strength, Synthetic, Non-absorbable, Sutures, Blue, Polypropylene, Monofilament.

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INTRODUCTION

Suture material is classified either as non-absorbable or absorbable. A non-absorbable suture material is much more slowly broken down over many months, and modern synthetics are much more inert. Non-absorbable sutures have high tensile strength, but lose between 10% and 15% of the tensile strength every year. It is a relatively elastic material and causes minimal tissue inflammation. And similarly non-absorbable sutures do not cause much tissue reaction. Absorbable suture is defined as suture that loses most of its tensile strength. The time it takes to be degraded in tissue varies by type of material. It has a high tensile strength, but the tensile strength decreases as the suture mass is absorbed. The absorbable sutures are available in monofilament or braided varieties [1].

The application of suture in surgery is very important, ranging from fascia, repair of tension band of fractures, joint capsules, and closure of surgical wounds, muscles, tendon, or ligaments. The quality of repair depends on variables such as the surgical technique, material properties suture, and tissue characteristics. The types of material that is used for suture have important implications in tissue repair. Adverse surgical outcomes can be avoided by selecting suitable suture materials [11]. Table 1 is a list of material for sutures obtained from previous publication.

Evaluations of suture are conducted continuously by group of purchasing organizations. The purchasing commission conducts research to survey materials managers, surgeons, and operating room supervisors, at member hospitals regarding their rating of product's clinical acceptability and their vendor preference [12]. These data will assist the surgeon in selection and application of appropriate suture materials to specific tasks [11].

The important properties of sutures are provided adequate tension for wound closure and non-reactivity for the least inflammatory response [13]. The purpose of this work is to provide the tensile strength data of commercial synthetic non-absorbable sutures made from blue polypropylene monofilament. The data of failure strain and modulus elasticity are also provided for consideration of the user.

METHODS

Commercial synthetic non-absorbable suture made from blue polypropylene monofilament was prepared in this research for tensile strength investigation. The suture was under trademark Corleone from the company of Peter Surgical, France.

The tested material was extracted from sterile packaging and referred from instruction from previous publication [13]; the samples then were immersed in alcohol for 1 day.

The average of the diameter sample measurements represented the mean diameter value for each material investigated as explained in previous publication [13]. The diameter measurements were performed on each sample of material at three different equidistant points of the sutures. The diameter of the sutures was measured using optical microscope (Olympus SZH 10).

Tensile testing has been performed to evaluate the tensile strength of sutures. The modulus elasticity (E) and strain (ε) are also presented. Five times repetition of valid tensile tests were conducted and average value of tensile test will be provided. The tensile strength test analysis has been carried out following standard test method for tensile strength

Table 1: The average diameter, tensile strength, failure strain, and modulus elasticity of the non-absorbable suture made from blue polypropylene monofilament

Samples	Average diameter (mm)	Tensile strength (MPa)		Failure strain		Modulus of elasticity (MPa)	
		Individual sample	Average	Individual sample	Average	Individual sample	Average
Sample 1	0.140	792.40	875.812	0.260	0.282	3815.262	4026.069
Sample 2	0.137	910.14		0.284		4270.442	
Sample 3	0.143	850.73		0.276		4014.909	
Sample 4	0.142	897.73		0.276		4026.755	
Sample 5	0.136	928.07		0.312		4026.069	

Table 2: Material for sutures from various source of publications

Sutures materials	References
Thermoplastic poly(carbonate) urethane	[2]
Polypropylene	[2,3]
Silk	[4-7]
Catgut	[8,9]
Nylon	[10]
Polydioxanone, Poly(glycolic acid)	[3]
Polyethylene, polyester, copolymerized lactide, and glycolide	[11]

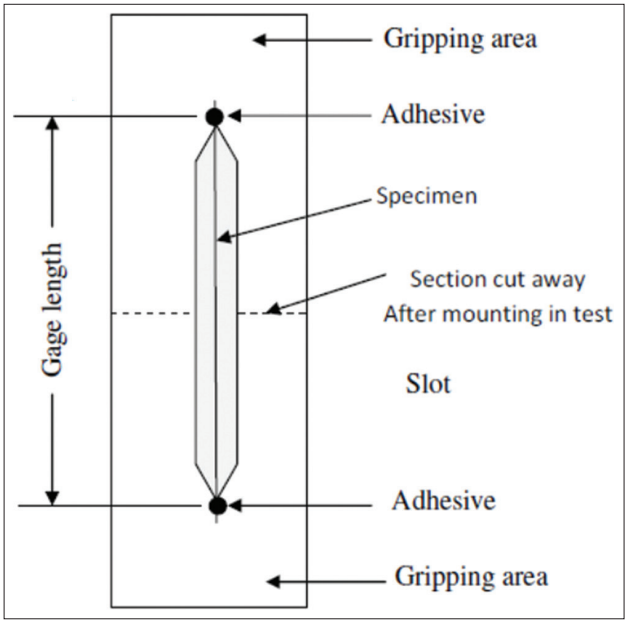

Fig. 1: Specimen mounting tab [14] for tensile test of the suture

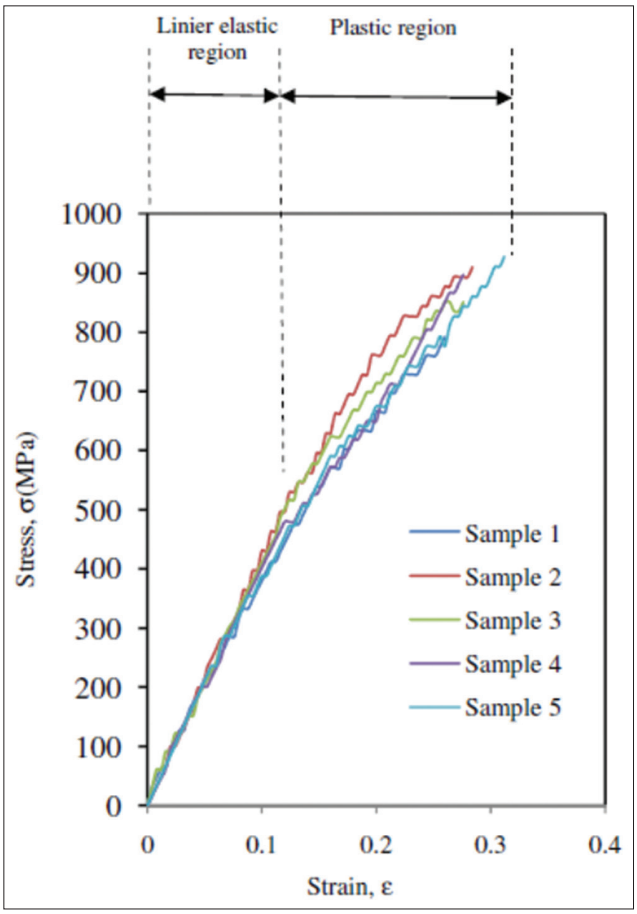

Fig. 2: The graph of strain versus stress of the sutures made from synthetic non-absorbable suture monofilament (blue polypropylene monofilament)

and modulus elasticity of fiber [14]. The load was measured by digital balance (Sartorius).

The mounting tab was utilized for specimen mounting. Schematic of the mounting tab for tensile test of the single fiber is presented in Fig. 1. Small amount glue is placed on the mounting tab. The fiber is bond to the mounting tab. The gauge length in this research was 50 mm and was defined as gauge length.

The tensile strength (σ) was calculated using Equation 1. Where A is across sectional area fracture plane normal to fiber axis (mm^2) and F is force to failure (N) [14].

$$\sigma = \frac{F}{A} \quad (1)$$

The tensile strain, ε (dimension less) was measured using Equation 2. Where L_0 (mm) was the gauge length and ΔL (mm) was elongation of the gauge length [14].

$$\varepsilon = \frac{\Delta L}{L_0} \quad (2)$$

The modulus elasticity E of the suture (MPa) was calculated using Equation 3 [14].

$$E = \frac{\sigma}{\varepsilon} \quad (3)$$

RESULTS AND DISCUSSION

The result of tensile strength of commercial synthetic non-absorbable suture made from blue polypropylene monofilament is presented in Table 2. It is found that the average tensile strength of five valid tested samples is about 875.812 MPa. The average failure strain is found about 0.282. The average of modulus of elasticity is about 4026.069 MPa.

The graph of strain versus stress from the tensile test of commercial synthetic non-absorbable suture made from blue polypropylene

Table 3: Comparison the tensile properties of absorbable sutures with non-absorbable sutures (this research)

Type of sutures	Material	Average tensile strength (MPa)	Average max. tensile strain	Average Young's modulus (MPa)
Natural absorbable [9]	Chromic catgut monofilament	392.276	0.143	2786.484
Synthetic absorbable [9]	Braided violet coated polyglycolide	1070.292	0.362	5321.328
Synthetic non-absorbable (this research)	Blue, polypropylene, monofilament	875.812	0.282	4026.069

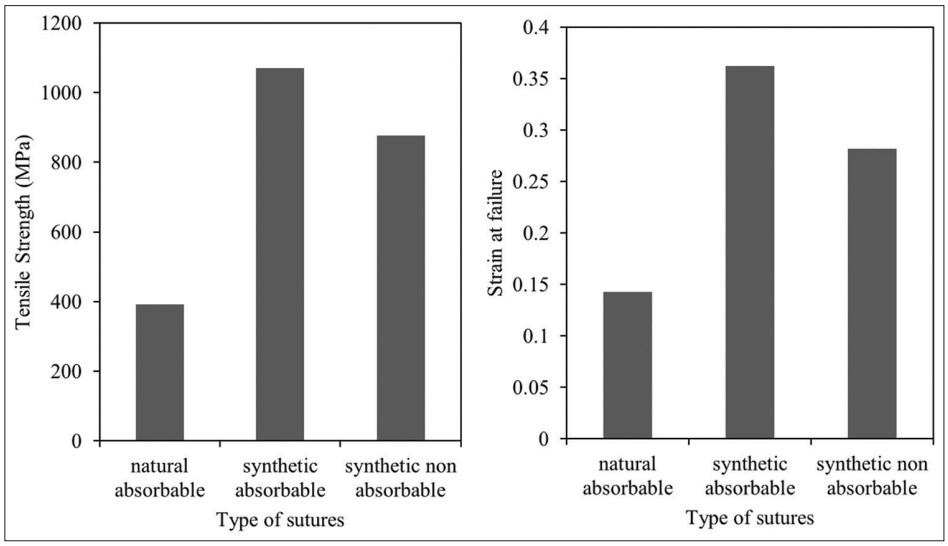

Fig. 3: Tensile strength and failure at strain of some sutures, namely, natural absorbable (chromic catgut monofilament) [9], synthetic absorbable (braided violet coated polyglycolide) [9], and synthetic non-absorbable (blue, polypropylene, monofilament) that is investigated in this work

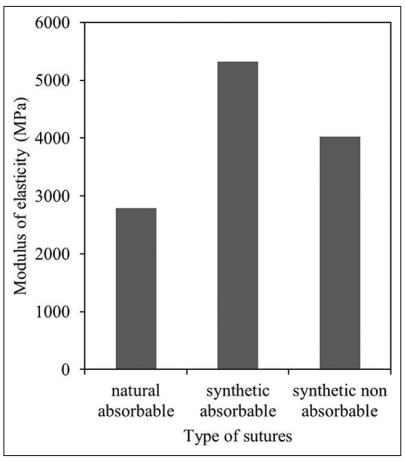

Fig. 4: Modulus elasticity of some sutures, namely: Natural absorbable (chromic catgut monofilament) [9], synthetic absorbable (braided violet coated polyglycolide [9], to be compared with synthetic non-absorbable (blue, polypropylene, monofilament) that is investigated in this research

monofilament can be analyzed from Fig. 2. The graph indicates that the suture having linier elastic region as well as plastic region.

It is important to compare the tensile strengthσ of commercial synthetic non-absorbable suture made from blue polypropylene monofilament as was conducted in this research to other type of sutures. This information will be importance information for the surgeon for decision during choosing type of sutures. Suture from other vendor than in this research may have different result because does not have equivalent performance profiles. Specific brand seems to be the most important determinant of physician evaluations of the different vendor's products. It is importance of conducting comparisons of multiple vendors [12].

Tensile strength data assist the surgeon in selection and application of appropriate suture materials to specific tasks [11]. Table 3 is comparison of tensile properties to absorbable sutures obtained from previous investigation [9]. The non-absorbable suture in this research is found superior above tensile strength of natural absorbable sutures (chromic catgut monofilament). Chromic gut was problems with suture security overtime [15]. However, if compare to synthetic absorbable suture (braided violet coated polyglycolide), the tensile strength of synthetic non-absorbable suture in this research is found a bit lower (Fig. 3). It should take into consideration also that braided sutures have greater strength and pliability making a knot less likely to slip, meaning fewer throws could result in a secure knot [16].

Instead braided violet coated polyglycolide having better tensile strength, previous publication also informed that polyglactin would be the best suture material with regard to tissue security and reaction scores [16].

Previous publication reports that non-absorbable surgical sutures, due to their antigenicity and/or the presence of bacterial infection, can cause granuloma formation after surgery [4]. Therefore, application of absorbable sutures is promoted due to this reason.

The strain failure of synthetic non-absorbable suture also is found lower comparing synthetic absorbable sutures (Fig. 3), this is due polyglycolide exhibits stress relaxation [3]. The highest modulus elasticity is found also in the synthetic absorbable suture (Fig. 4), which means that suture made from synthetic braided violet coated polyglycolide is more stiffness than synthetic non-absorbable in this research.

The difficulty was faced during conducting this research. The material that was tested in this research was in micron size. Therefore the tensile test of the sutures should be done by experienced technician.

Future work: The degradation strength of the sutures after surgeon will be investigated as future work.

CONCLUSION

Tensile test of non-absorbable sutures was conducted in this research. The material is blue, polypropylene, monofilament. It is found that the average tensile strength of five valid tested samples is about 875.812 MPa. The average strain ε is found about 0.282. The average of modulus of elasticity is 4026.069 MPa. The sutures having both linier elastic and plastic property.

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