

Original Research Article

Comparison of tensile strength of skin closure by simple interrupted, simple continuous, and staples

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Received: 05 July 2023

Revised: 07 August 2023

Accepted: 14 August 2023

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ABSTRACT

Background: Objective of the study was to compare tensile strength and time taken for wound closure using simple interrupted sutures, simple continuous sutures, and staples sutures.

Methods: Swine skin tissue was cut into pieces of 2×6 cm and were divided into 3 groups according to skin closure technique: simple interrupted sutures (Nylon 5-0), simple continuous sutures (Nylon 5-0), and staples suture. All sutures, three equal knots in one piece, were performed by a single surgeon. Time taken for the approximation of each sample was recorded in second (S). Tensile strength was measured in newton unit (N) by pulling apart until suture separation using a tensiometer. One-way analysis of variance (ANOVA) and subgroup analysis using Bonferroni correction was used to determine differences between groups.

Results: Of 190 total pairs of skin tissue, the mean±SD times for skin approximation were 144.86±22.67 s for simple interrupted sutures, 96.19±17.64 s for simple continuous sutures, and 12.90±3.18 s for staples sutures (p<0.001). The corresponding mean±SD of maximum tensile strengths in each group were 29.04±10.72 N, 18.85±5.45 N, and 56.41±19.56 N, respectively (p<0.001).

Conclusions: Our study showed that the use of staples for skin approximation took the least operative time and achieved the highest maximum tensile strength.

Keywords: Skin closure, Simple interrupted sutures, Simple continuous sutures, Staples, Tensile strength

INTRODUCTION

Head and neck are anatomically related structures, comprising of different organs and tissues. Surgery in this region presents at least 2 important concerns: aesthetic and function issues. This area is visible and representing an individual, so a restoration of normal anatomy is needed. Being a highly mobile structure, any surgery of head and neck requires very high-tension sutures to keep surgical wound intact until removed.

Wound dehiscence is a common complication after surgeries, especially in procedures that require a tension-

free primary closure. Dehiscence is frequently related to flap and suture tension. Many modern closure techniques and suture materials have been developed for the scalp and neck area, such as nylon simple sutures, continuous sutures, staples, synthetic intradermal glue, and absorbable sutures. These are selectively used depending on the specific surgical site of head and neck which required different tensile strength. Other factors which are generally considered are: time to achieve closure, cost, cosmetic outcomes, pain during suture removal, and a capability of wound healing of the individuals, and systemic illness which might cause vascular deterioration and delayed

wound healing e.g. prior radiation therapy or diabetes mellitus.

Regarding the tensile strength, multiple influencing factors are recognized: mobility of suture area, suture technique, and suture material. Few studies assessed and found different tensile strength among various techniques of suturing. Gonzalez-Barnadas et al assessed the tensile strength of 3 suture techniques (simple suture, horizontal mattress suture, and a combination of both) using 4 different materials.¹ They found combined suture achieved the highest tensile strength compared with either simple or mattress sutures. Zellner et al compared suture placement time, tension at skin separation and suture line failure among 4 suture patterns (simple interrupted, cruciate, intradermal, or subdermal).² Mean tensile strength at skin-edge separation and suture-line failure for the simple interrupted and cruciate patterns were significantly higher than those for the intradermal and subdermal patterns.

For suture material, Batra et al compared skin staples with conventional suture materials for closure of incision wounds of head and neck cancer.³ They found staples were better alternatives than the other sutures in terms of being faster and with comparable results of patient comfort, aesthetic outcome, and complication rates, so more cost effective.

However for a cosmetic outcome, Iqbal et al who reported subcuticular sutures are superior to metal clips because they are economical, easy to remove with good cosmetic results.⁴ Lal et al studied comparison between skin suture and skin staplers found outcome of staplers is cosmetically superior to skin sutures with overall less complication as compared to skin sutures.⁵ Ridgway et al concluded glued skin may increase the duration of surgery but acceptable neck mobility and cosmesis.⁶ While staples have more rapid application.

With inconsistent results from previous reports, this study aimed to compare staple suture with other suture materials using different techniques. The outcomes of interest were operating (suturing) time and tensile strength.

METHODS

Ex vivo skin specimens

The study was conducted as an experimental study. This study has been approved by the Research Ethics Review Committee for Research Involving Human Subjects, Faculty of Medicine Vajira Hospital. Research was not involved human subject. We study during April to May 2019 in Faculty of Industrial Education and technology, King Mongkut's University of Technology Thonburi, Thailand.

The present study examined the end-to-end closure of abdominal porcine skin. Swine skin tissue was cut into pieces of 2×6 cm, placed longitudinally on the knife board,

and were approximated according to 3 groups according to wound-closure techniques: conventional simple, continuous sutures, and staples sutures (Figure 1).

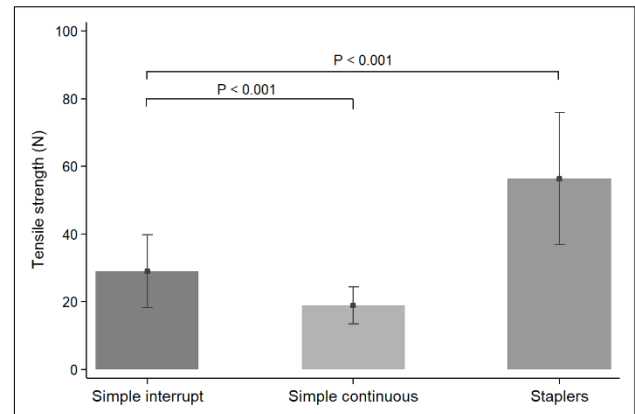


Figure 1: Simple interrupt, simple continuous and staplers' tensile strength box plot.

Each piece of sample, using curve cutting needle, was sutured in 3 stitches by a single surgeon (C.C.). In brief, the needle with suture material was inserted into the skin approximately 3 mm from the edges, passed perpendicularly through the epidermis and dermis, crossed the incision, and perpendicularly up through the dermis and epidermis to exit 3 mm from the opposite edge. Suture techniques were simple interrupt sutures (3 tied knots) in the first group and continuous suture (3 tied knot) in the second group. The suture material in both groups was non-absorbable Nylon 5-0 (Ethilon® black monofilament). The third group received three staples (6 Proximate® Plus MD) 0.5 cm apart. All suture techniques are shown in Figure 1.

The operating (suturing) times from the beginning (needle insertion to the skin) to the last tied knot were recorded in second (sec) by the surgeon.

All sutured pieces of specimens were measured tensile strength by tensiometer (Hounsfield®) (Figure 3). A sutured specimen was individually mounted in the metal tissue-gripping fixture of tensiometer (Figure 2). The fixture consisted of 2 metal plates with a corrugated inner surface that squeeze the specimen together with 2 turn screws on each side. The upper and lower fixture were allowed to move up and down to allow even distribution of force over the length of the specimen in opposite directions to measure the maximum tensile strength. Traction was performed at a speed 1 mm/min. The maximum load (in N) was registered when the suture untied or broke. We duplicate to perform the test with different techniques.

Sample calculation

A sample calculation was performed with G*power 3.1.9.4 software. An alpha error was set at 0.05 and power at 0.85.

A total of 141 samples (47 in each group) were need. This number was increased to 195 (65 in each group) to compensate for possible errors during the procedure.

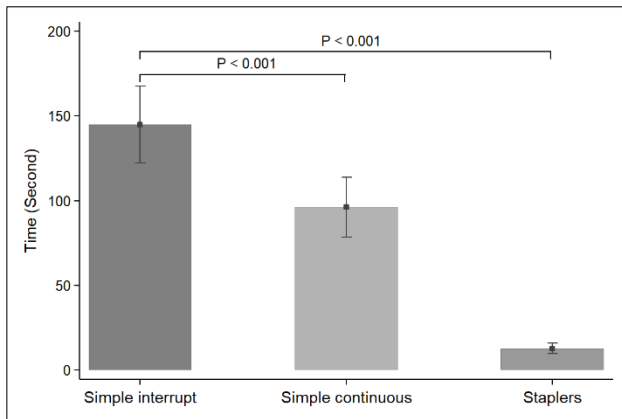


Figure 2: Simple interrupt, simple continuous and staplers time box plot.



Figure 3: Tensiometer machine.

Statistical analysis

The statistical analysis was performed with IBM statistical package for the social sciences (SPSS) statistics for window version 23.0 (IBM Corp, Armonk, NY). Statistical analysis performed using one-way analysis of variance (ANOVA). Multiple groups were compared by Bonferroni analysis. The statistical significance was set at p value <0.001.

RESULTS

From 195 pieces of swine skin, 4 were excluded to improve statistic outcome. (1 in simple continuous suture and 3 in staple suture groups). The remaining 190 samples were included in the analysis: 64 in simple interrupted, 65 in simple continuous, and 61 in staples groups.

Simple interrupt suture consumed the longest suturing time whereas staple suture used the shortest time. The average times of sutures in descending order were: 144.86 sec (SD 22.67 sec) of simple interrupted, 96.19 sec (SD

17.64 sec) for simple continuous, and 12.90 sec (SD 3.18 sec) for staple sutures (p<0.001). The time of each suturing are shown in Table 1.

Table 1: Result of tension and time in each technique.

Method of sutured	Tension		Time	
	Mean (N)	SD (N)	Mean (sec)	SD (sec)
Simple sutured	29.04	10.72	144.86	22.67
Continuous sutured	18.85	5.45	96.19	17.64
Staplers	56.41	19.56	12.90	3.18

The suture which yielded strongest tensile strength was staples suture followed by simple interrupted and simple continuous sutures. The differences were statistically significant (p<0.001), with the mean±SD maximum tensile in order of their strengths were 56.41±19.56 N, 29.04±10.72 N, and 18.85±5.45 N, respectively (Table 1).

DISCUSSION

The present study compared the tensile strength of skin closed using simple interrupted sutures, simple continuous sutures, and staples. Staples showed statistically significant greatest tensile strength than the others. Other studies show similar findings. Shapiro compared the strength required to disrupt 4 methods of wound closure: 2-octyl cyanoacrylate glue, surgical staples, steri-strips (0.5 inch width), and interrupted 4-0 poliglecaprone subcuticular suture.⁷ Staples provided the strongest closure. According to Batra staples was reported to be a good choice for wound closure as they required less time to achieve wound closure and were associated with less pain during the procedure, no pain during removal material, no complications, and greater aesthetic outcome.³ One disadvantage of staples is its higher cost than conventional suturing materials with either simple interrupted or simple continuous suture technique.

Regarding the speed of wound closure, which is also important, we found shortest suturing time with staples. It was more than 10 times quicker than simple continuous and simple interrupt sutures (p<0.001). Other studies show similar findings. Kochar and Singh reported wound closure with staples was almost three times faster but with less tensile strength of scar tissue than with other types of sutures.⁸ Gupta also showed staplers had benefit in terms of less time and expenses consumed.⁹ One randomized control trial by Rouse compared staples to subcuticular sutures for cesarean sections abdominal skin closure in 101 women.¹⁰ Significantly shorter operative time and less pain at 6 weeks was found with staples suture.

Overall, in comparison to conventional simple interrupt and simple continuous sutures, the staple technique showed the greatest benefit in in both aspects of tensile strength and duration of suturing.

Regarding other types of wound closure, other studies reported superior aesthetic outcomes with synthetic glue and adhesive strips than the other means of wound closure.¹¹⁻¹³ Further prospective clinical studies should address the tensile strength, aesthetic outcome as well as pain or discomfort comparing staples with these less invasive techniques.

The present study used porcine abdominal skin which has similar physical texture to human head and neck skin. Our results should be applicable to clinical practice. We recommended that the scalp closure which requires high tensile strength should consider using the staples technique. Although staplers were reported to be superior to skin sutures in terms of less complications, minimal scar and aesthetic outcomes, pain or patient's discomfort as well as wound complications and aesthetic outcomes could not be assessed in our study.^{3,5}

CONCLUSION

Staples showed the greatest tensile strength and the shortest time to achieve wound closure compared with conventional simple interrupted and continuous sutures. Skin staples are better alternatives to conventional sutures in head and neck cancer surgery as they offer ten times faster wound closure, cost effectiveness, and similar results to sutures in terms of patient comfort, aesthetic outcome and complication rate.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Jarasviriyagul N, Chanasriyotin C. Comparison of tensile strength of skin closure by simple interrupted, simple continuous, and staples. *Int Surg J* 2023;10:1439-42.