International Surgery Journal
Ananda BB et al. Int Surg J. 2019 Mar;6(3):775-782
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: http://dx.doi.org/10.18203/2349-2902.isj20190489

Original Research Article

A comparative study between conventional skin sutures, staples adhesive skin glue for surgical skin closure

Ananda B. B., Vikram J., Ramesh B. S., Hosni Mubarak Khan*

Department of General Surgery, KMC, Dr. BRAMCH Bangalore, Karnataka, India

Received: 03 October 2018
Revised: 30 January 2019
Accepted: 06 February 2019

***Correspondence:**
Dr. Hosni Mubarak Khan,
E-mail: drhosnimubarakkhan@gmail.com

ABSTRACT

Background: The signature of a surgeon is 'scar'. Skin closure technique should be technically easy, acceptable, speedy and economical. Sutures and staples remain the mainstay of techniques. However, the use of GLUE is increasing in clinical practice. Authors compared all the three techniques in terms of time efficacy, post-operative pain, wound complications, cosmesis and cost-effectiveness.
Methods: A 2-year prospective randomized controlled study was conducted on 90 healthy patients comparing tissue glue, staplers and sutures in primary wound closures following elective surgeries in the Department of General Surgery at BRAMC (October 2015 to October 2017).
Results: The patients in the three groups were analyzed using chi-square, ANOVA, Fisher Exact test, and results were formulated. Staples consumed less time for application with a mean of 53.3 seconds when compared to glue (103.97 seconds) and sutures (294.97 seconds). Glue gave best results in terms of less post-operative pain. Mean VAS score calculated at 12,24,48,72 hrs was 63.13,42.10,16.94,7.27 and at 7 days was 4.73. The wound ASEPSIS score calculated on 3rd, 5th, and 7th day. Cosmesis score on 7th day, 1st month and 5th month was calculated using modified hollander and VAS cosmesis scale. Mean score with glue was 5.83,88.90 and 96.13 respectively. Cost of material including length of hospital stay for glue was also effective with 3.47 days on an average. All the above proved statistical significance.
Conclusions: Staples application is faster, consumes less significant time than glue and sutures. Skin glue gives the best results in terms of less post-operative pain, wound asepsis, better cosmesis and cost-effectiveness. The concept of tissue glue is a safe, attractive, and effective alternate over other conventional methods of wound closures following elective surgeries.

Keywords: Modified hollander scale, Octyl-2-cyanoacrylate, Staplers, Sutures, Tissue glue, VAS, Wound closure

INTRODUCTION

In the pre-historic era, many natural sources like honey were used as antibacterial solutions. These conventional methods are still practiced in contemporary daily wound management. In the recent past of 1960s and 1970s polymeric dressings were introduced in different forms and were custom made. Currently the ever-expanding discoveries combine everything in a nutshell finally to provide optimal wound healing.

Wound closure from pre-historic till date has evolved with mankind. Numerous techniques and developments have occurred in management and closure of wounds. Closing of wounds to achieve an aesthetically pleasing scar has always been a challenge. The ideal surgical wound would be as strong as normal tissue, the moment

it is closed. Douglas and Forester found that the maximum strength in the tissue that could be regained after wound closure is 80% even on one year follow-up.[1]

Wound closure technique has evolved widely over the period of time. Various methods of skin closure are available in places of traditional sutures like staples, tapes and adhesive compounds.[2] The optimal method of skin closure should be simple, safe, rapid, inexpensive, painless, bactericidal and aesthetically appealing scar.

Although the conventional skin suturing is a gold standard technique for wound closuring since many years, staples and adhesive glues have entered the clinical practice more recently. Modern surgical staplers are either disposable and made of plastic or reusable and made of stainless steel. Staples carry the advantages of rapid speed of closure, lesser chance of infection, improved wound eversion without tissue strangulation, minimal cross hatch scarring and less foreign body reaction. It eliminates the risk of needle stick injury from unknown patient's histories for health care providers.[3-5]

The cyanoacrylates originally gained fame in 1958 as a super strong, fast drying glue, marketed.[6] The most widely used tissue adhesives nowadays come from alkyl cyanoacrylates.[7] The choice of wound closure after surgery has always been a matter of debate. The essence of modern surgeon nowadays depends on the quality called judgement - the ability to know what to use, when to use and how long to use. All the above skin closure techniques differ from each other and have their own merits and demerits. The gold standard technique for a particular wound still remains controversial. Selection of a wrong closure technique for a defined wound could become disastrous. Hence the need to study various aspects of different types of skin closure techniques in comparison between skin suturing, skin staples and adhesive skin glue is warranted.

Aims and objectives

To compare between the three methods of skin closures i.e., conventional skin suturing, staples and adhesive glue in surgical skin closure for the following characters.

- To compare time efficacy between the three methods of closure.
- To compare cost between the three methods.
- To compare the cosmetic appearance of skin after closure by the 3 methods.
- To Compare Surgeon preference and patient satisfaction between the 3 methods.
- To compare post-operative pain and any other complications between the 3 methods

METHODS

In this comparative prospective study 90 patients were included wherein, 30 in each group undergoing surgery admitted in the Department of General Surgery in Dr. B. R. Ambedkar Medical College Hospital, Bangalore. The study conducted between October 2015 to October 2017.

Total of 90 patients in good general health undergoing open inguinal hernioplasty, open appendicectomy, lipoma excision and open cholecystectomy were selected for the study. Following these surgeries, after subcutaneous approximation to close dead space and appose wound edges patients were randomly selected to three groups. In group A, incisions were closed with glue (octyl-2-cyanoacrylate) using propen. Octyl-2-cyanoacrylate was applied in a thin layer over the entire wound, extending 5-10mm beyond wound edge using propen.

Table 1: ASEPSIS score.[13,14]

Wound characteristic	0	Proportion of wound affected				
		<20	20-39	40-59	60-79	>80
serious exudates	0	1	2	3	4	5
Erythema	0	1	2	3	4	5
purulent exudates	0	2	4	6	8	10
Separation deep tissues	0	2	4	6	8	10
Points are scored for daily wound infection						
Additional treatment					Points	
Antibiotics					10	
Drainage of pus under local anesthesia					5	
Debridement of wound (general anesthesia)					10	
Serous discharge*					Daily 0-5	
Erythema*					Daily 0-5	
purulent exudate*					Daily 0-5	
Separation deep tissues*					Daily 0-5	
Isolation of bacteria					10	
Stay as inpatient prolonged over 14 days					5	
*Given score only on 5 to 7 days. Highest weekly score used. Category of infection -Total						
score 0-10: Satisfactory healing ,11-20: Disturbance of healing, 20-30: Minor wound infection,						
>40: Severe Wound infection (Wilson AP et al)[16]						

The wound was allowed to dry for 15-20 sec and then second layer and third layers were applied. No additional bandaging was done. In group B, incisions were closed with non-absorbable skin staples applied in a single layer while keeping the margins of the incised wound together using forceps. In group C, incisions were closed with non-absorbable nylon sutures in sub-cuticular stlyle (ethilon 3-0). After taking detailed history and thorough examination of the patients, routine blood investigations like complete haemogram, BT, CT, HIV, HBsAg, blood sugars, blood urea and serum creatinine (other relevant investigations if required). Same antibiotic protocol was followed i.e. injection cefotaxime 1gm was given iv at the time of induction of anaesthesia.

In all 3 groups, the time taken to close the incised wound using a particular method was noted using a stopwatch timer and compared. The post-operative pain was assessed at 12 h, 24 h, 48 h, 72 hrs and 7th day using Visual Analog Scale of 0-100. 0 being no pain and 100 is worst pain possible as rated by patient themselves. The outcome of wound was assessed at 3rd, 5th, 7th post-operative day (POD) using the standard wound asepsis scoring system from 0 to 10 (Table 1).

The wound was assessed for cosmesis on the 7th POD using modified Hollander cosmesis scale of 1-6. A score of 6 was considered as optimal while 5 or less as suboptimal. On the follow-up, 1st and 3rd month, wound cosmesis is assessed by independent blinded observer and wound scoring done using Visual Analog Cosmesis Scale of 0-100. A score of 0 being worst cosmesis and that of 100 being excellent cosmesis.

- Step off the borders, (0 for yes, 1 for no)
- Contour irregularities - puckering, (0 for yes, 1 for no)
- Wound margin separation, (0 for yes, 1 for no)
- Wound edge inversion, (0 for yes, 1 for no)
- Excessive wound distortion, (0 for yes, 1 for no)
  Good overall appearance (0 for poor, 1 for acceptable).

Inclusion criteria

Cases undergoing clean elective surgical procedures and skin closure with conventional skin suturing or staples or adhesive skin glue under the same antibiotic coverage during same period from October 2015 to October 2017.

Exclusion criteria

- Critical cases undergoing damage control surgery.
- Cases for whom stomas are necessary.
- Patients who are unable to come for follow-up on 7th or 15th post-operative days.
- Wounds on face, bony prominences and highly mobile areas for stapler closure.
- Wounds on mucocutaneous junctions link lips, friction sites like hands and feet for adhesive glue application.
- Patients with h/o DM, immunosuppresion, malignancy, scars or keloid formation.

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean±SD (Min-Max) and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance. The following assumptions on data is made:

Assumptions

- Dependent variables should be normally distributed.
- Samples drawn from the population should be random, Cases of the samples should be independent.

Statistical analysis

Analysis of variance (ANOVA) has been used to find the significance of study parameters between three or more groups of patients.

Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups, Non-parametric setting for Qualitative data analysis. Fisher exact test used when cell samples are very small.

P value significance

- + Suggestive significance (P value: $0.05<P<0.10$)
- * Moderately significant (P value: $0.01<P \leq 0.05$)
- ** Strongly significant (P value: $P \leq 0.01$).

The Statistical software namely SPSS 18.0, and R environment ver.3.2.2 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

A total of 90 patients were recruited.30 in each were included randomly among the suturing, stapling and skin glue group. Mean age group was 41.11 with a percentage of 20% falling under 31-50 years. The mean age in the skin glue was 41.20 yrs ±20.91, skin staples was 43.30 yrs ±18.63 and the mean age in the suturing group was 41.20yrs ±20.9. Male sex was predominant with 65 patients (72.2%) in total (Table 2). The following four surgeries were performed - open appendicectomy, lipoma excision, open cholecystectomy and hernioplasty. Authors selected patients in equal numbers from all the groups undergoing the procedures. This was to get a better outcome from all the groups in an unbiased manner and for comparing variables equally. The following graph shows the equal distribution of population among the procedures undergone in the respective groups.

In present study patients were chosen with incision length ranging from 1-10cms. Number of seconds in which the wound was closed was calculated among the three groups using a stop watch. Present study shows that 22 number of patients i.e., 73.3% among the staple population took only less than 60 seconds. whereas 29 patients i.e., 96.7% among the glue population took 60-200 seconds. But suture population took the highest amount of time i.e., more than 200 seconds among the three groups.

The visual analogue score (VAS) (Table 3) calibrated from 0-100 was used to calculate the pain score at 12,24,48,72 hours and at the end of 7 days gave us the following results. 12 hours post operatively the pain score was least in the glue population (mean was 63.13), 24

hours post operatively also pain was minimum in glue population (42.10) and 48 hours also glue had the least pain score (16.97). 72 hours post operatively again glue scored the least among the three population.

Table 2: The following four surgeries were performed - open appendicectomy, lipoma excision, open cholecystectomy and hernioplasty.

Variable	Glue	Staples	Sutures	Total
Age (Mean + SD)	41.20±20.91	43.30±18.63	38.38±17.40	41.11±18.91
Female	10(33.3%)	6(20%)	9(30%)	25(27.8%)
Male	20(66.7%)	24(80%)	21(70%)	65(72.2%)
Surgical procedure				
Hernioplasty	15(50%)	15(50%)	15(50%)	45(50%)
Open appendicectomy	7(23.3%)	7(23.3%)	7(23.3%)	21(23.3%)
Lipoma excision	4(13.3%)	4(13.3%)	4(13.3%)	12(13.3%)
Open cholecystectomy	4(13.3%)	4(13.3%)	4(13.3%)	12(13.3%)
Incision Length (cms) (Mean + SD)	6.53±1.33	6.43±1.38	6.57±1.43	6.51±1.37
Time taken for wound closure (Mean + SD)	103.97±17.22	53.30±8.93	294.97±42.82	150.74±108.03
Complications				
Serous Exudate	3(10%)	5(16.7%)	5(16.7%)	13(14.4%)
Erythema	2(6.7%)	3(10%)	10(33.3%)	15(16.7%)
Purulent exudates	0(0%)	1(3.3%)	2(6.7%)	3(3.3%)
Wound gaping	1(3.3%)	1(3.3%)	2(6.7%)	4(4.4%)
Length of hospital stay	3.47±0.97	5.93±4.65	6.80±5.24	5.40±4.28

Table 3: Post-operative pain in three groups of patients.

Post operative pain	Glue	Staples	Sutures	Total	P value
12 hrs	63.13±16.73	70.80±14.1	81.87±10.19	71.93±15.8	<0.001**
24 hrs	42.10±12.50	46.50±12.57	61.30±10.78	49.97±14.44	<0.001**
48 hrs	16.97±9.41	24.83±8.11	35.47±11.96	25.76±12.45	<0.001**
72 hrs	7.27±5.46	11.93±8.07	18.47±11.50	12.56±9.77	<0.001**
7 days	4.73±5.35	8.67±14.77	11.27±14.73	8.22±12.59	0.129

Table 4: ASEPSIS score distribution in three groups of patients.

Asepsis Score	Glue (n=30)	Staples (n=30)	Sutures (n=30)	Total (n=90)	P value
Day 3					
0	26(86.7%)	23(76.7%)	16(53.3%)	65(72.2%)	0.016*
1-10	4(13.3%)	7(23.3%)	14(46.7%)	25(27.8%)	
11-20	0(0%)	0(0%)	0(0%)	0(0%)	
>20	0(0%)	0(0%)	0(0%)	0(0%)	
Mean±SD	0.60±1.65	1.07±2.20	1.53±1.89	1.07±1.94	
Day 5					
0	29(96.7%)	26(86.7%)	23(76.7%)	78(86.7%)	0.084+
1-10	1(3.3%)	4(13.3%)	7(23.3%)	12(13.3%)	
11-20	0(0%)	0(0%)	0(0%)	0(0%)	
>20	0(0%)	0(0%)	0(0%)	0(0%)	
Mean±SD	0.27±1.46	0.70±2.09	0.87±1.68	0.61±1.76	
Day 7					
0	29(96.7%)	28(93.3%)	28(93.3%)	85(94.4%)	1.000
1-10	1(3.3%)	1(3.3%)	1(3.3%)	3(3.3%)	
11-20	0(0%)	0(0%)	0(0%)	0(0%)	
>20	0(0%)	1(3.3%)	1(3.3%)	2(2.2%)	
Mean±SD	0.13±0.73	0.97±4.93	1.20±5.86	0.77±4.42	

Table 5: Cosmesis Score distribution in three groups of patients.

Cosmesis	Glue (n=30)	Staples (n=30)	Sutures (n=30)	Total (n=90)	P value
7th Day					
0	0(0%)	1(3.3%)	1(3.3%)	2(2.2%)	
1-3	0(0%)	0(0%)	1(3.3%)	1(1.1%)	0.770
4-6	30(100%)	29(96.7%)	28(93.3%)	87(96.7%)	
Mean±SD	5.83±0.46	5.30±1.15	5.13±1.28	5.42±1.06	
1st month					
0-20	0(0%)	0(0%)	0(0%)	0(0%)	
21-40	0(0%)	1(3.3%)	0(0%)	1(1.1%)	
41-60	0(0%)	1(3.3%)	5(16.7%)	6(6.7%)	<0.001**
61-80	3(10%)	14(46.7%)	18(60%)	35(38.9%)	
81-100	27(90%)	14(46.7%)	7(23.3%)	48(53.3%)	
Mean±SD	88.90±5.85	79.77±13.24	72.03±12.40	80.23±12.90	
5th month					
0-20	0(0%)	0(0%)	0(0%)	0(0%)	
1-40	0(0%)	0(0%)	0(0%)	0(0%)	
41-60	0(0%)	1(3.3%)	2(6.7%)	3(3.3%)	0.057+
61-80	0(0%)	1(3.3%)	4(13.3%)	5(5.6%)	
81-100	30(100%)	28(93.3%)	24(80%)	82(91.1%)	
Mean±SD	96.13±3.52	92.93±8.71	89.10±11.49	92.72±8.95	

This is statistically significant with the 'p' value being <0.001. Hence this study has statistically proven with strong significance that pain is minimum with glue compared to staples and sutures. Out of the 90 patients population 13 experienced serous exudates from the site as a complication of skin closure. Among the patients who had erythema the least was in glue population followed by staples and finally the sutures. Presence of purulent exudates from the wound was noted in the all the three groups.

ASEPSIS score (Table 4) is calculated using the parameters as explained in methodology. Lesser the score was better for the outcomes. This score was calculated on day 3, day 5 and day 7 post-operatively. Overall lesser ASEPSIS score was observed among the glue population with statistical significance for POD 3 and suggestive significance on POD 5. However statistical significance could not be proved on day 7, though glue group had the best asepsis score on comparison with a wider range.

Wounds of patients in all the three groups were assessed for cosmesis on 7th day, using Modified Hollander Cosmesis Scale (Table 5). 1st and 5th month using VAS for cosmesis. The material costs were suggestive of the fact that suture materials were the most cost - effective of the three methods of skin closure.

The cost-effectiveness was further evaluated in terms of total post-operative hospital stay. Authors can statistically signify that patients in the glue population required the least number of hospital stay followed by staples and then suture groups with a 'p' value of 0.006 proving strong significance.

DISCUSSION

In the present study all the three methods of skin closure technique which were, the conventional suturing and the two sutureless techniques - staples and glue were compared.

Age

Present study comprised of population with age group between 31-50 years in majority. The mean age in glue population was 41.20 years, staples was 43.30 years and in sutures it was 38.38 years. However, age relation in comparison with disease condition and surgeries underwent was not attempted which could interfere with wound healing and bias.

Gender

Present present study had a male predominance with 72.2% in total and 27.8% of female population.

Incision length

As depicted in the present study the length of incision was 0-10cms. Thus, the adhesive was used to close only small or medium sized operative wounds. This again corresponds to the above discussed limitation of cyanoacrylates (Dermabond), that they cannot be used in the closure of long skin wounds. Many workers evaluated

this material only in a particular type of wound, like Adoni et al, used tissue adhesive for the closure of episiotomy wounds.[8] Samuel PR et al, and Maw JL et al, evaluated this material in skin wounds resulting from head and neck surgery.[9,10] In another study conducted by Simon HK et al, cyanoacrylate was shown to be a preferred method of cutanenous closure of lacerations oriented against the langer's lines.[11] So, in none of the studies, adhesive material was tried for the closure of long skin wounds.

Time taken for skin closure

In a study conducted by Ridgway et al, average time taken for closure of cervicotomy incision in neck surgeries with glue was much more than with skin staplers with a mean difference of 67 sec.[12] Reported average time for skin closure in the adhesive group to be 100 sec and the average time for the placement of staples was 30 sec in patients undergoing arthroplasty i.e. TKR or THR.[13] According to Chibbaro et al, there was no significant difference between surgical adhesive glue and skin staples for closure of neurosurgical scalp incisions.[14]

Present study shows that staple population wound closure time was less when compared with glue and sutures. This comparison had a strong statistical significance explaining that staple closure had taken lesser time for wound closure when compared to glue and sutures.

Post-operative pain

Post-operative pain was assessed through the visual analog scale by the patients themselves. The present study showed comparatively less post-operative pain in the glue group followed by staples group then in the skin suturing group as measured at 12hrs, 24hrs, 48hrs, 3rd day and 7th day interval. Similar studies conducted by Gaertner et al, and BI Singh et al, which have shown that abdominal wounds closed with sutures have been associated with increased post-operative pain, support the outcome of this present study.[15,16]

Earlier studies by Zempsky et al, Arunachalam et al, have compared the post-operative pain using a visual analog scale and shown less post-operative pain following adhesive glue closures but had failed statistical significance.[17,18] Strong statistical significance was proved in our study explaining that people in whom glue was used had less post-operative pain when compared to staples and sutures.

Complications / ASEPSIS score

In present study we observed the presence of serous exudates, purulent exudates, erythema and wound gaping among the three groups. This showed that only erythema had a statistically significant comparison, which explained that the glue population had lesser chances of erythema when compared with staples and sutures.

Khan et al, and Chibbaro et al, had no significant difference as regards with serous collection in their studies between both groups.[13,14] Cases in staple group developed gaping as compared to glue group. Data from four well-known trials contributed to the meta-analysis found that there was an overall significant difference detected between the proportion of wounds with dehiscence, favoring closure by suture with no evidence of heterogeneity.[19-22] However, Blondeel et al, in a series of 209 patients treated with octyl-2- cyanoacrylate and commercially available devices following closure of long surgical incisions concluded that the new tissue adhesive formulation provides epidermal wound closure equivalent to commercially available devices with a trend to decreased incidence of wound infection.[23]

Present study also significantly explained that the ASEPSIS score in glue population was less compared with the other two groups, which says that the usage of glue had lesser chances of infection rates when compared with staples and sutures. This had a strong 'p' value significance on day 3. Day 5 was suggestive of significance.

Wound cosmesis

Patients in the three groups were assessed for the cosmetic outcome of the wound on the 7th post-operative day, 1st month and 3rd month using Modified Hollander and VAS Cosmesis scale. On the 7th Post-operative day the mean cosmesis score for all the three groups was numerically in favour of glue and this difference could not be proved as statistically significant. At the end of one month the mean cosmesis score showed numerical widening between the three groups under study and this statistically strongly signified that glue group had better cosmesis when compared with the other two. At the end of 3 months the mean cosmesis scores for the three groups were moderately close, as close as 96.13 for glue, 92.93 for staples and 89.10 for sutures with suggestive statistical significance.

Keng et al, in a randomized series of 43 patients whose operations involved a groin incision found that the glued wounds had consistently better cosmetic scores (mean score 4.71 at 4 weeks) compared to subcuticular wounds (mean score 4.00 at 4 weeks) with a $P < 0.05$.[24] Present study with strong significance had showed that usage of glue had better cosmesis than staples and sutures.

Cost-effectiveness

The material costs were suggestive of the fact that suture materials were the most cost-effective of the three methods of skin closure. The cost increased when closure was done with polyglactin sutures for subcuticular closure of skin. The glue group had a significantly lesser hospital stay compared to the other groups in our study which had strong statistical significance. Christopher Jones S et al, for economic outcome, it was found that

overall it was significantly more economical to use skin adhesive (20.3 Euros) than sutures (29.3 Euros) (p <0.001).[25] The authors conclude that there was little to choose between the methods of closure in terms of outcome but economically glue had the edge over sutures.

A study from Texas, USA, included an economic evaluation of the cost of closing laparoscopic wounds with either 4-0 Monocryl/Vicryl or cyanoacrylate glue.[26] They found a mean cost saving of $303 per patient in the cyanoacrylate group, resulting from time saved during surgery. All these articles support our study in favor, which says that glue was more cost-effective than staples and sutures with strong 'p' value significance.

CONCLUSION

The present prospective comparative study between Adhesive skin glue, skin staples and sutures conclude that the glue group seems to have better toleration towards pain in post-operative period, lesser wound complication rate, lesser post-op stay in the hospital an overall better cosmetic outcome. However, a longer application time than the staples and slightly higher cost than the sutures was involved.

Overall, with additional advantage of being bacteriostatic and no post-operative removal required, adhesive skin glue merits to be the closure method of choice for a desired wound.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Douglas DM, Forrester JC, Ogilvie RR. Physical characteristics of collagen in the later stages of wound healing. Br J Surg. 1969 Mar;56(3):219-22.
2. Materials of wound closure. April 12, 2005. Available at: www.emedicine.com.
3. Margaret Terhune, MD, Private Practice, Richmond Dermatology and Laser Specialists. Materials for wound closure. Updated: Nov 10, 2009.
4. Hochberg J, Meyer KM, Marion MD. Suture choice and other methods of skin closure. Surg Clin. 2009 Jun 1;89(3):627-41.
5. Lloyd JD, Marque III MJ, Kacprowicz RF. Closure techniques. Emergency Med Clin North Am. 2007 Feb 1;25(1):73-81.
6. Cool HW. Chemistry and performance of cyanoacrylate adhesives. J Soc Plast Eng. 1959;15:413-7.
7. Watson DP. Use of cyanoacrylate tissue adhesive for closing facial lacerations in children. Br Med J. 1989 Oct 21;299(6706):1014.
8. Zaki I, Scerri L, Millard L. Split skin grafting on severely damaged skin a technique using absorbable tissue adhesive. J Dermatol Surg Oncol. 1994;20(12):827-9
9. Samuel PR, Roberts AC, Nigam A. The use of indermil (n-butyl cyanoacrylate) in otorhinolaryngology and head and neck surgery a preliminary report on the first 33 patients. J Laryngol Otol. 1997;111(6):536-40.
10. Maw JL, Quinn JV, Wells GA, Ducic Y, Odell PF, Lamothe A, Brownrigg PJ, Sutcliffe T. A prospective comparison of octylcyanoacrylate tissue adhesive and suture for the closure of head and neck incisions. J Otolaryngol. 1997;26(1):26-30.
11. Simon HK, Zempsky WT, Bruns TB, Sullivan KM. Lacerations against Langer's lines: to glue or suture?. J Emerg Med. 1998;16(2):185-9.
12. Ridgway DM, Mahmood F, Moore L, Bramley D, Moore PJ. A blinded, randomised, controlled trial of stapled versus tissue glue closure of neck surgery incisions. Ann R Coll Surg Engl. 2007;89(3):242-6.
13. Khan RJ, Fick D, Yao F, Tang K, Hurworth M, Nivbrant B, et al. A comparison of three methods of wound closure following arthroplasty: a prospective, randomised, controlled trial. J Bone Joint Surg Br. 2006;88(2):238-42
14. Chibbaro S, Tacconi L. Use of skin glue versus traditional wound closure methods in brain surgery: a prospective, randomized, controlled study. J Clin Neurosci. 2009;16(4):535-9.
15. Gaertner I, Burkhardt T, Beinder E. Scar appearance of different skin and subcutaneous tissue closure techniques in caesarean section: a randomized study. Eur J Obstet Gynecol Reprod Biol. 2008;138:29-33.
16. Singh BI, Mcgarvey C. Staples for skin closure in surgery. BMJ. 2010 Apr 3;340:c403.
17. Zempsky WT, Parrotti D, Grem C, Nichols J. Randomized controlled comparison of cosmetic outcomes of simple facial lacerations closed with Steri Strip™ skin Closures or Dermabond™ tissue adhesive. Pediatr Emergency Care. 2004 Aug 1;20(8):519-24.
18. Arunachalam P, King P, Orford J. A prospective comparison of tissue glue versus sutures for circumcision. Pediatr Surg Int. 2003 Apr 1;19(1-2):18-9.
19. Cheng W, Saing H. A prospective randomized study of wound approximation with tissue glue in circumcision in children. J Paediatr Child Health. 1997 Dec;33(6):515-6.
20. Shamiyeh A, Schrenk P, Stelzer T, Wayand WU. Prospective randomized blind controlled trial comparing sutures, tape, and octylcyanoacrylate tissue adhesive for skin closure after phlebectomy. Dermatol Surg. 2001 Oct 1;27(10):877-80.
21. Sinha S, Naik M, Wright V, Timmons J, Campbell AC. A single blind, prospective, randomized trial comparing n-butyl 2-cyanoacrylate tissue adhesive

(Indermil) and sutures for skin closure in hand surgery. J Hand Surg. 2001 Jun;26(3):264-5.
22. Switzer EF, Dinsmore RC, North Jr JH. Subcuticular closure versus Dermabond: a prospective randomized trial. Am Surg. 2003 May 1;69(5):434-6.
23. Blondeel PN, Murphy JW, Debrosse D, Nix III JC, Puls LE, Theodore N, et al. Closure of long surgical incisions with a new formulation of 2-octylcyanoacrylate tissue adhesive versus commercially available methods. Am J Surgery. 2004 Sep 1;188(3):307-13.
24. Keng TM, Bucknall TE. A clinical trial of tissue adhesive (histoacryl) in skin closure of groin wounds. Med J Malaysia. 1989;44(2):122-8.
25. Jones CD, Ho W, Samy M, Boom S, Lam WL. Comparison of glues, sutures, and other commercially available methods of skin closure: A review of literature. Med Res Arch. 2017 Jul 15;5(7).
26. Sebesta MJ, Bishoff JT. Octylcyanoacrylate skin closure in laparoscopy. J Endourol. 2003 Dec 1;17(10):899-903.

Cite this article as: Ananda BB, Vikram J, Ramesh BS, Khan HM. A comparative study between conventional skin sutures, staples adhesive skin glue for surgical skin closure. Int Surg J 2019;6:xxx-xx.