American Journal of
Biomedical Science & Research

www.biomedgrid.com
ISSN: 2642-1747

Research Article

Comparative Study of Surgical Site Wound Infection Rates in Patients with Dynamic Hip Screw Fixation Skin Closure with Polypropylene Suture Versus Metallic Skin Staples

Muhammad Inam, Anwar Hassan, Ibrahim Khan and Imran Khan*

Department of Orthopedic and Trauma, Medical Teaching Institute Lady Reading Hospital Peshawar, Pakistan

***Corresponding author:** Imran Khan, Department of Orthopedic and Trauma, Medical Teaching Institute Lady Reading Hospital Peshawar, Pakistan.

To Cite This Article: *Imran Khan. Comparative Study of Surgical Site Wound Infection Rates in Patients with Dynamic Hip Screw Fixation Skin Closure with Polypropylene Suture Versus Metallic Skin Staples. Am J Biomed Sci & Res. 2023 19(1) AJBSR.MS.ID.002550,*

DOI: 10.34297/AJBSR.2023.19.002550

Received: May 25, 2023; **Published:** June 02, 2023

Abstract

Objectives: To compare frequency of surgical site wound infection rates of skin closure in patients with dynamic hip screw with polypropylene versus metallic skin staples.

Material and Methods: This Randomized control trial study was conducted in the Department of Orthopedic surgery, Medical Teaching Institute Lady Reading Hospital, Peshawar Pakistan form June 13, 2022, till December 12, 2022on 122 Patients, aged 20 to 60 years of both gender with inter-trochanteric fractures undergoing dynamic hip screw fixation were enrolled using non-probability consecutive sampling technique. The study was conducted after approval of hospital ethical committee and written informed consent of patients. Data was entered and analyzed using SPSS.

Results: In our study 122 patients were enrolled, 61 patients in each group. Mean age was 37±13.1 years in group A and 35.3±12.1 years in group B. There were 60.7% males in group A and 50.8% in group B. females were 39.3% in group A and 49.2% in group B. Mean duration on injury was 12.7±3.9 days in group A and 13.7±3.8 in group B. Surgical site infection was 11.5% in staple group and 19.7% in suture group but p-value was not significant i.e., 0.212.

Conclusion: surgical site infection is less in staple group, but it is not statistically significant.

Keywords: Femur fracture, Polypropylene, Staple closure, Suture closure, Surgical wound, Surgical site

Introduction

Surgical Site Infections (SSI) remain an important concern after orthopedic surgery. While the most common SSIs are superficial wound infections, even these seemingly minor events may lead to serious complications, including deep infections, prosthetic joint infections, sepsis, and revision surgery. SSIs place an increased burden on the healthcare system, increasing length of stay, re-hospitalization rates, and healthcare costs, and adversely affect patient quality of life and function [1,2]. Surgical Site Infections (SSIs) are one of the most common and important complications after hip surgery. Patients with early incision infections after hip surgery have poor clinical scores in terms of postoperative pain and function. Some incision infections may spread inward, leading to deep infections and failure of the prosthesis [3]. Complications of wound after Orthopedic surgery is a cause of major morbidity resulting in prolonged hospital stay, frequent hospital admissions and limiting post-operative physical mobility and quality of life of these patients [4].

After the completion of the surgical procedure, the skin closure is done. The optimal goal of skin closure is to promote rapid healing and an acceptable cosmetic result while minimizing the risk of in-

fection. Skin closure after hip surgery is done by using either of the two widely used sutures i.e., polypropylene (Prolene) sutures or the staple sutures. Prolene sutures are made up of a synthetic steroisomer known as polypropylene. It is a monofilament non-absorbable, sterile surgical suture. They are indicated for use in general soft tissue. It provides permanent tensile strength retention in tissue, even in the presence of infection. These sutures are exceptionally smooth for an easy passage through the tissue [5]. Controversial results have been shown by various studies comparing complication rates and efficacy of skin staples and sutures and no consensus has been obtained in the literature as to which method of skin closure is superior [6,7]. Some authors suggest that although metal staples are costly and associated with greater chances of wound complications, the closure is rapid [8]. Others reported a lower rate of complication with staples when compared with suture closure. While some researchers documented no significant difference in wound complication rates between the staples and sutures [4]. Variable rates of surgical site infections have been reported in literature. One study reported SSI rate of 18% with staples closure and 16% with suture closure (p>0.05) [4]. Another study reported Surgical Site Infections (SSIs) of 61.2% versus 38.8% (p value 0.024) for suture and staples groups respectively [8]. It is hypothesized that Skin closure in patients of dynamic hip screw with skin stapler has lower rate of surgical site infections than suture.

The rationale of this study is that in our institution post Dynamic Hip Screw (DHS) skin closure is done according to the surgeon preferences. We conducted this study to formulate standard guidelines for skin closure.

Materials and Methods

This Randomized control trial study was conducted in the Department of Orthopedic surgery, Medical Teaching Institute Lady Reading Hospital, Peshawar Pakistan form June 13, 2022, till December 12, 2022, on 122 Patients, aged 20 to 60 years of both gender with inter-trochanteric fractures undergoing dynamic hip screw fixation were enrolled using non-probability consecutive sampling technique. Patients with open fractures, pathological fractures, revision hip surgery and polytrauma patients with multiple fractures will be excluded from the study. Sample size was calculated using WHO calculator keeping 95% confidence interval, 80 % power of study, frequency of surgical site infections 38.8% in staple group and in 61.2% propylene suture group [7]. Sample size was 122 patients, 61 patients in each group.

After approval from the hospital ethical board, patients fulfilling the inclusion criteria were enrolled from orthopedic indoor of LRH. A written informed consent was taken after explaining the purpose of study. Demographic data including age, gender, duration of injury, diabetes, hypertension, smoking, and obesity was noted. Complete history was taken, and physical examination was done. Baseline labs including CBC, LFT, RFT, serum electrolyte and chest x-ray were done for general anesthesia fitness. All surgeries were performed by the same experienced orthopedic surgeon in a clean Orthopedic operation theatre. A uniform standard surgical protocol was adopted for all the patients including application of Op-site® at the incision site and preoperative intravenous Cefuroxime 1.6gm in each case. Skin closure was done after closure of fascia and subcutaneous tissue with absorbable vicryl. Patients were randomly divided into two groups using computer generated random numbers of squares. Skin closure of all the patients in the staple group (Group A) was closed using a commercially available skin stapler (®Adan F-35,6mm wide by Ningbo Advani Electrical Co Ltd China) while the suture group (Group B) skin was closed with interrupted polypropylene monofilament, non-absorbable (®Prem Ilene 2/0, straight cutting, 75cm, B-Braun Spain) mattress sutures. The staples and sutures were placed 1cm apart with an assistant approximating the skin edges with forceps ahead of staple application. The wound was covered with pyrene-soaked gauze and crept bandage. Suction drainage was used in all cases and removed after 24 to 48 hours.

The first post op dressing, and wound examination was done while the patient was discharging home from hospital usually on 3rd to 5th day. An intravenous antibiotic (Etoperidone plus Sulbactam 2gm) was prescribed for 2 to 3 days to all the patients. Further follow-up visits were done in the 1st and 2nd weeks and surgical site infection was noted as per operational definition. Staples or sutures were removed at two weeks with a sterilized clip remover, forceps, and blade respectively. Patients having surgical site infection were treated as per hospital protocol. Data was entered in a specially designed proforma. Data was entered and analyzed by using SPSS version 22.0. Mean and standard deviation was calculated for quantitative variables like age and duration of injury. Frequency and percentage were calculated for categorical variables like gender, diabetes, hypertension, obesity, smoking and surgical site infection. Surgical site infections in both groups were compared using chi square test, p-value≤0.05 was taken as statistically significant. Effect modifiers like age, gender, duration of injury, diabetes, hypertension, smoking, and obesity were addressed through stratification of data against frequency of SSI. Post stratification chi square was applied, p-value≤0.05 was taken as statistically significant.

Results

In our study 122 patients were enrolled, 61 patients in each group. Mean age was 37±13.1 years in group A and 35.3±12.1 years in group B (Table 1).

There were 60.7% males in group A and 50.8% in group B. females were 39.3% in group A and 49.2% in group B (Table 2).

The mean duration of injury was 12.7±3.9 days in group A and 13.7±3.8 in group B (Table 3).

Diabetes was 26.2% in group A and 18% in group B (Table 4).

Hypertension was 45.9% in group A and 44.3% in group B (Table 5).

Smoking was 21.3% in group A and 27.9% in group B (Table 6).

Obesity was 24.6% in group A and 29.5% in group B (Table 7).

Surgical site infection was 11.5% in staple group and 19.7% in suture group, but p-value was not significant i.e., 0.212 (Table 8).

Data stratification was done for age groups, gender, duration of disease, diabetes, hypertension, smoking and obesity (Tables 9-15).

Table 1: Age of Sampled Population.

	Group	N	Mean	Std. Deviation	Std. Error Mean	p-value
Age (Year)	Group A (Staple group)	61	37.05	13.189	1.689	0.468
	Group B (Suture group)	61	35.38	12.131	1.553	

Table 2: Gender Distribution.

			Gender		Total
			Male	Female	
Group	Group A (Staple group)	Count	37	24	61
		% within Group	60.7%	39.3%	100.0%
	Group B (Suture group)	Count	31	30	61
		% within Group	50.8%	49.2%	100.0%
p-value 0.274					

Table 3: Mean Duration of Injury.

	Group	N	Mean	Std. Deviation	Std. Error Mean	p-value
Duration (Days)	Group A (Staple group)	61	12.72	3.967	.508	0.138
	Group B (Suture group)	61	13.77	3.801	.487	

Table 4: Frequency of Diabetes.

			Diabetes		Total
			Yes	No	
Group	Group A (Staple group)	Count	16	45	61
		% within Group	26.2%	73.8%	100.0%
	Group B (Suture group)	Count	11	50	61
		% within Group	18.0%	82.0%	100.0%
p-value 0.276					

Table 5: Frequency of Hypertension.

			Hypertension		Total
			Yes	No	
Group	Group A (Staple group)	Count	28	33	61
		% within Group	45.9%	54.1%	100.0%
	Group B (Suture group)	Count	27	34	61
		% within Group	44.3%	55.7%	100.0%
p-value 0.856					

Table 6: Frequency of Smoking.

			Smoking		Total
			Yes	No	
Group	Group A (Staple group)	Count	13	48	61
		% within Group	21.3%	78.7%	100.0%
	Group B (Suture group)	Count	17	44	61
		% within Group	27.9%	72.1%	100.0%
p-value 0.400					

Table 7: Frequency of Obesity.

			Obesity		Total
			Yes	No	
Group	Group A (Staple group)	Count	15	46	61
		% within Group	24.6%	75.4%	100.0%
	Group B (Suture group)	Count	18	43	61
		% within Group	29.5%	70.5%	100.0%
p-value 0.541					

Table 8: Comparison of Frequency of Surgical Site Infection in Both Groups.

			Surgical site infection		Total
			Yes	No	
Group	Group A (Staple group)	Count	7	54	61
		% within Group	11.5%	88.5%	100.0%
	Group B (Suture group)	Count	12	49	61
		% within Group	19.7%	80.3%	100.0%
p-value 0.212					

Table 9: Data Stratification for Frequency of Ssi in Both Groups and Age Groups.

Age groups				Surgical site infection		Total	p-value
				Yes	No		
20-40 years	Group	Group A (Staple group)	Count	3	23	26	0.959
			% within Group	11.5%	88.5%	100.0%	
		Group B (Suture group)	Count	3	22	25	
			% within Group	12.0%	88.0%	100.0%	
	Total		Count	6	45	51	
			% within Group	11.8%	88.2%	100.0%	
41-60 years	Group	Group A (Staple group)	Count	4	31	35	0.139
			% within Group	11.4%	88.6%	100.0%	
		Group B (Suture group)	Count	9	27	36	
			% within Group	25.0%	75.0%	100.0%	
	Total		Count	13	58	71	
			% within Group	18.3%	81.7%	100.0%	

Table 10: Data Stratification for Frequency of Ssi in Both Groups and Gender.

Gender				Surgical site infection		Total	p-value
				Yes	No		
Male	Group	Group A (Staple group)	Count	3	34	37	0.173
			% within Group	8.1%	91.9%	100.0%	
		Group B (Suture group)	Count	6	25	31	
			% within Group	19.4%	80.6%	100.0%	
	Total		Count	9	59	68	
			% within Group	13.2%	86.8%	100.0%	
Female	Group	Group A (Staple group)	Count	4	20	24	0.754
			% within Group	16.7%	83.3%	100.0%	
		Group B (Suture group)	Count	6	24	30	
			% within Group	20.0%	80.0%	100.0%	
	Total		Count	10	44	54	
			% within Group	18.5%	81.5%	100.0%	

Table 11: Data Stratification for Frequency of Ssi in Both Groups and Duration of Disease.

Duration				Surgical site infection		Total	p-value
				Yes	No		
Equal to or less than 14 days	Group	Group A (Staple group)	Count	3	36	39	0.132
			% within Group	7.7%	92.3%	100.0%	
		Group B (Suture group)	Count	6	24	30	
			% within Group	20.0%	80.0%	100.0%	
	Total		Count	9	60	69	
			% within Group	13.0%	87.0%	100.0%	
More than 14 days	Group	Group A (Staple group)	Count	4	18	22	0.915
			% within Group	18.2%	81.8%	100.0%	
		Group B (Suture group)	Count	6	25	31	
			% within Group	19.4%	80.6%	100.0%	
	Total		Count	10	43	53	
			% within Group	18.9%	81.1%	100.0%	

Table 12: Data Stratification for Frequency of Ssi in Both Groups and Diabetes.

Diabetes				Surgical site infection		Total	p-value
				Yes	No		
Yes	Group	Group A (Staple group)	Count	3	13	16	0.488
			% within Group	18.8%	81.2%	100.0%	
		Group B (Suture group)	Count	1	10	11	
			% within Group	9.1%	90.9%	100.0%	
	Total		Count	4	23	27	
			% within Group	14.8%	85.2%	100.0%	
No	Group	Group A (Staple group)	Count	4	41	45	0.082
			% within Group	8.9%	91.1%	100.0%	
		Group B (Suture group)	Count	11	39	50	
			% within Group	22.0%	78.0%	100.0%	
	Total		Count	15	80	95	
			% within Group	15.8%	84.2%	100.0%	

Table 13: Data Stratification for Frequency of Ssi in Both Groups And Hypertension.

Hypertension				Surgical site infection		Total	p-value
				Yes	No		
Yes	Group	Group A (Staple group)	Count	1	27	28	0.019
			% within Group	3.6%	96.4%	100.0%	
		Group B (Suture group)	Count	7	20	27	
			% within Group	25.9%	74.1%	100.0%	
	Total		Count	8	47	55	
			% within Group	14.5%	85.5%	100.0%	
No	Group	Group A (Staple group)	Count	6	27	33	0.703
			% within Group	18.2%	81.8%	100.0%	
		Group B (Suture group)	Count	5	29	34	
			% within Group	14.7%	85.3%	100.0%	
	Total		Count	11	56	67	
			% within Group	16.4%	83.6%	100.0%	

Table 14: Data Stratification for Frequency of Ssi in Both Groups and Smoking.

Smoking				Surgical site infection		Total	p-value
				Yes	No		
Yes	Group	Group A (Staple group)	Count	3	10	13	0.977
			% within Group	23.1%	76.9%	100.0%	
		Group B (Suture group)	Count	4	13	17	
			% within Group	23.5%	76.5%	100.0%	
	Total		Count	7	23	30	
			% within Group	23.3%	76.7%	100.0%	
No	Group	Group A (Staple group)	Count	4	44	48	0.161
			% within Group	8.3%	91.7%	100.0%	
		Group B (Suture group)	Count	8	36	44	
			% within Group	18.2%	81.8%	100.0%	
	Total		Count	12	80	92	
			% within Group	13.0%	87.0%	100.0%	

Table 15: Data Stratification for Frequency of Ssi in Both Groups and Obesity.

Obesity				Surgical site infection		Total	p-value
				Yes	No		
Yes	Group	Group A (Staple group)	Count	7	8	15	0.261
			% within Group	46.7%	53.3%	100.0%	
		Group B (Suture group)	Count	5	13	18	
			% within Group	27.8%	72.2%	100.0%	
	Total		Count	12	21	33	
			% within Group	36.4%	63.6%	100.0%	
No	Group	Group A (Staple group)	Count	0	46	46	0.004
			% within Group	0.0%	100.0%	100.0%	
		Group B (Suture group)	Count	7	36	43	
			% within Group	16.3%	83.7%	100.0%	
	Total		Count	7	82	89	
			% within Group	7.9%	92.1%	100.0%	

Discussion

In the context of orthopedic surgery, Surgical Site Infection (SSI)-defined as the occurrence of wound infection following surgery are frequent postoperative complications that represent 20% of all nosocomial infections [9,10]. SSIs are clinically classified as the occurrence of infection 5152 affecting either the superficial or deep incision sites within 30 days postoperatively or within 1 year if an implant is left inside the patient. [10]. Orthopedic SSIs are frequent postoperative complications that represent 20% of all nosocomial infections. In addition, orthopedic SSIs have been shown to extend postoperative hospital stay, double hospital readmission rates, and increase annual healthcare costs up to 300% [11,12]. Unfortunately, orthopedic SSIs also inflict a tremendous burden on the patient, often increasing physical limitations and reducing postoperative quality of life [13]. In response to the critical need to reduce the incidence of SSIs, a wealth of research has been published identifying effective preoperative, intra-operative and postoperative strategies to reduce the incidence of SSIs. 1 Preoperative strategies include increasing host immune status, prophylactic antibiotic administration and proper sterilization of the patient and all surgical staff [14]. During surgery, it is imperative that the surgical environment is properly ventilated, all surgical equipment is sterilized, and the use of proper surgical technique is employed [15]. Postoperatively, incisions should be properly wrapped with sterile dressing and proper sterile techniques should be used during dressing changeover [16].

With the increased pressure on orthopedic surgeons to promote rapid wound healing, reduce postoperative Length of Stay (LOS) and complications, the method of skin closure during surgery has become increasingly important [17-19]. The optimal goal of skin closure, 'is to promote rapid skin healing and an acceptable cosmetic result while minimizing the risk of dehiscence or infection'. In orthopedic surgery, the most common skin closure methods are the use of staples or sutures [20,21]. Yet, there seems to be no consensus in the literature as to which closure method is superior, with some studies reporting no difference and others reporting a higher wound complication rate following the use of staples [22-23]. This study was done to compare SSI after staple use and suture in intertrochanteric femur fracture in our population in our study 122 patients were enrolled, 61 patients in each group. Mean age was 37±13.1 year in group A and 35.3±12.1 years in group B. There were 60.7% males in group A and 50.8% in group B. females were 39.3% in group A and 49.2% in group B. Mean duration on injury was 12.7±3.9 days in group A and 13.7±3.8 in group B. Diabetes was 26.2% in group A and 18% in group B. Hypertension was 45.9% in group A and 44.3% in group B. Smoking was 21.3% in group A and 27.9% in group B. Obesity was 24.6% in group A and 29.5% in group B. Surgical site infection was 11.5% in staple group and 19.7% in suture group but p-value was not significant i.e. 0.212.

Controversial results have been shown by various studies comparing complication rates and efficacy of skin staples and sutures and no consensus has been obtained in the literature as to which method of skin closure is superior [6, 7]. Some authors suggest that although metal staples are costly and associated with greater chances of wound complications, the closure is rapid [8]. Others reported a lower rate of complication with staples when compared with suture closure. While some researchers documented no significant difference in wound complication rates between the staples and sutures [4]. Variable rates of surgical site infections have been reported in literature. One study reported SSI rate of 18% with staples closure and 16% with suture closure (p>0.05) [4]. Another study reported Surgical Site Infections (SSIs) of 61.2% versus 38.8% (p value 0.024) for suture and staples groups respectively [8].

In another study done in Germany a total of 61 patients underwent lower limb surgery, twenty-nine patients received staple wound closures, while 32 patients received nylon suture closures. Four patients with staple sutures and five with nylon sutures experienced wound dehiscence 14 days postoperatively, p-value was>0.05. However, all patients had completely healed wounds at their 6-week follow-up [24]. A study done in Pakistan Surgical site skin closure of 100 patients were done with staples (group A, 50 patients) and interrupted polypropylene suture (group B, 50 patients). The baseline parameters of both groups had no significant differences. Mean age of group A and B patients were 61.6±SD 17.1 and 61.02±SD 19.2 respectively. Surgical site wound complications were reported in 9(18%) patients with staples closure and 8(16%) patients with suture closure (p>0.05) [25]. A meta-analysis was done in 2016, 13 studies were included in cumulative meta-analysis conducted using Review Manager V.5.0. The risk ratio was computed as a measure of the treatment effect taking into account heterogeneity. Random-effect models were applied. There was no significant difference in infection comparing sutures to staples. The cumulative relative risk was 1.06 (0.46 to 2.44). In addition, there was no difference in infection comparing sutures to staples in hip and knee surgery, respectively [26]. In another study there were 33 (22%) suspected infections within the six-week follow-up period in lower limb surgeries. Review of the charts of all suspected infections confirmed two infections, one in a sutured wound and one in a stapled wound. There was no difference in the rate of suspected SSI between the sutures (18) and staples (13) group (RR=0.77, CI=0.42-1.41) [27]. All these studies validate the results of our study.

Conclusion

We found no significant difference in surgical site complication rates of staples and suture closure in intertrochanteric femur fracture surgery patients. The operating surgeon can use closure material of his own choice taking into consideration the availability and cost of closure material.

Acknowledgments

None.

Conflict of Interest

None.

References

1. Badiha JM, Casey AL, Petrocelli N, Hudson PM, Mitchell SA, et al. (2017) Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries. J Hosp Infect 96(1): 1-15.
2. Krishnan RJ, Crawford EJ, Syed I, Kim P, Rampersaud YR, et al. (2019) Is the risk of infection lower with sutures than with staples for skin closure after orthopedic surgery? A meta-analysis of randomized trials. Clin Orthop Relat Res 477(5): 922-937.
3. Liu Z, Liu B, Yang H, Zhao L (2021) Staples versus sutures for skin closure in hip arthroplasty: a meta-analysis and systematic review. J Orthop Surg Res 16(1): 735.
4. Shah FA, Ali MA, Khan UZ (2018) Surgical site wound complication; a comparative study of surgical site wound complication rates of metallic skin staples versus polypropylene sutures in orthopedic wound closure. Professional Med J 25(10): 1487-1491.
5. Hasan O, Jawaani A, Mazhar L, Begum D, Lakdawala R, et al. (2021) Comparison of surgical site infection after skin closure by proline or staples in bilateral simultaneous knee arthroplasty patients: A parallel design randomized controlled trial protocol. Int J Surg Protoc 25(1): 154-159.
6. Yuenyongviwat V, Thanaphon K, Hungarian T, Tangtrakulwanich B (2016) A randomized controlled trial comparing skin closure in total knee arthroplasty in the same knee: Nylon sutures versus skin staples. Bone Joint Res (5): 185-190.
7. Daniilidis K, Stukenborg Colsman C, Ettinger S, Claassen L, Plaass C, et al. (2020) Nylon sutures versus skin staples in foot and ankle surgery: is there a clinical difference? Musculoskelet Surg 104(2):163-169.
8. Cochetti G, Abraha I, Randolph J, Montedori A, Boni A, Arezzo A, et al. (2020) Surgical wound closure by staples or sutures? Systematic review. Medicine 99(25): e20573.
9. Mangram AJ, Horan TC, Pearson ML (1999) Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 20: 250-78.
10. Li G, Guo F, Ou Y (2013) Epidemiology and outcomes of surgical site infections following orthopedic surgery. Am J Infect Control 41: 1268-71.
11. Saadatian Elahi M, Teyssou R, Vanhems P (2008) Staphylococcus aureus, the major pathogen in orthopedic and cardiac surgical site infections: a literature review. Int J Surg 6(3): 238-45.
12. Whitehouse JD, Friedman ND, Kirkland KB (2002) The impact of surgical-site infections following orthopedic surgery at a community hospital and a university hospital: adverse quality of life, excess length of stay, and extra cost. Infect Control Hosp Epidemiol 23(4): 183-189.
13. Bachoura A, Guitton TG, Smith RM (2011) Infirmity and injury complexity are risk factors for surgical-site infection after operative fracture care. Clin Orthop Relat Res 469(9): 2621-30.
14. Owens CD, Stoessel K (2008) Surgical site infections: epidemiology, microbiology and prevention. J Hosp Infect 70(Suppl 2):3-10.
15. Smith TO, Sexton D, Mann C (2010) Sutures versus staples for skin closure in orthopedic surgery: meta-analysis. BMJ 340: c119.
16. Singh B, Mowbray MAS, Nunn G (2006) Closure of hip wound, clips or subcuticular sutures: does it make a difference? Eur J Orthop Surg Traumatol 16(2): 124-129.
17. Khan RJ, Fick D, Yao F (2006) A comparison of three methods of wound closure following arthroplasty: a prospective, randomised, controlled trial. J Bone Joint Surg Br 88: 238-242.
18. Shetty AA, Kumar VS, Morgan Hough C (2004) Comparing wound complication rates following closure of hip wounds with metallic skin staples or subcuticular vicryl suture: a prospective randomised trial. J Orthop Surg (Hong Kong) 12(2): 191-193.
19. Livesey C, Wylde V, Descamps S (2009) Skin closure after total hip replacement: a randomised controlled trial of skin adhesive versus surgical staples. J Bone Joint Surg Br 91(6): 725-729.
20. Clayer M, Southwood RT (1991) Comparative study of skin closure in hip surgery. Aust N Z J Surg 61(5): 363-365.
21. Eldrup J, Wied U, Andersen B (1981) Randomised trial comparing proximate stapler with conventional skin closure. Acta Chir Scand 147(7): 501-502.
22. Chughtai T, Chen LQ, Salasidis G (2000) Clips versus suture technique: is there a difference? Can J Cardiol 16: 1403-1407.
23. Stockley I, Elson RA (1987) Skin closure using staples and nylon sutures: a comparison of results. Ann R Coll Surg Engl 69(2): 76-78.
24. Daniilidis K, Stukenborg Colsman C, Ettinger S, Claassen L, Plaass C, et al. (2020) Nylon sutures versus skin staples in foot and ankle surgery: is there a clinical difference? Musculoskelet Surg 104(2): 163-169.
25. Shah FA, Ali MA, Khan UZ (2018) Surgical site wound complication; a comparative study of surgical site wound complication rates of metallic skin staples versus polypropylene sutures in orthopaedic wound closure. Professional Med J 25(10): 1487-149.
26. Krishnan R, MacNeil SD, Malvankar Mehta MS (2016) Comparing sutures versus staples for skin closure after orthopaedic surgery: systematic review and meta-analysis. BMJ Open 6(1): e009257.
27. Slade Shantz JA, Vernon J, Morshed S, Leiter J, Stranges G (2013) Sutures versus staples for wound closure in orthopaedic surgery: a pilot randomized controlled trial. Patient Saf Surg 7(1): 6.