



# Wound Complications in Joint Arthroplasty: Comparing Traditional and Modern Methods of Skin Closure

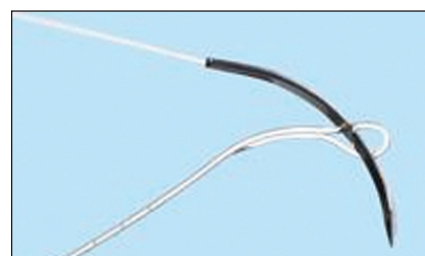
RONAK M. PATEL, MD; MAX CAYO, BS; ARPAN PATEL, BS; MARIE ALBARILLO, PA-C; LALIT PURI, MD, MBA

## abstract

Full article available online at [Healio.com/Orthopedics](http://Healio.com/Orthopedics). Search: 20120426-16

Various methods of skin closure exist in joint replacement surgery. Although subcuticular skin closure techniques offer an aesthetic advantage over conventional skin stapling, no measurable differences have been reported. Furthermore, newer barbed sutures, such as the V-Loc absorbable suture (Covidien, Mansfield, Massachusetts), theoretically distribute tension evenly through the wound and help decrease knot-related complications. The purpose of this study was to evaluate whether wound complication rates were (1) lower in V-Loc closure cases as theoretically suggested, (2) lower for subcuticular closure vs staples, and (3) significantly different for knee and hip joint reconstruction.

A retrospective chart review was conducted of 278 consecutive cases of primary joint reconstruction performed by a single surgeon (L.P.). The study group comprised 106 men and 161 women. Average patient age at surgery was 63 years (range, 18-92 years), and average body mass index of the cohort was 33.7 kg/m<sup>2</sup> (range, 25-51 kg/m<sup>2</sup>). Skin was closed via staple gun or subcuticular stitch (3-0 Biosyn [Covidien] vs V-Loc). Seven (3.9%) wound complications occurred in 181 cases closed with staples. Four (7.8%) wound complications occurred in 51 cases closed via subcuticular Biosyn suture. Six (13.0%) wound complications occurred in 46 cases closed with V-Loc suture. The staple group had a lower rate of complications when compared with the suture group as a whole ( $P=.033$ ) and when compared specifically with the V-Loc suture group ( $P=.017$ ).



**Figure:** Image of V-Loc barbed suture with unidirectional barbs (Covidien, Mansfield, Massachusetts).

*Drs Patel (Ronak) and Puri, Messrs Cayo and Patel (Arpan), and Ms Albarillo are from the Department of Orthopaedic Surgery, Feinberg School of Medicine, Northwestern University, Chicago, Illinois.*

*Dr Patel (Ronak), Messrs Cayo and Patel (Arpan), and Ms Albarillo have no relevant financial relationships to disclose. Dr Puri is a paid consultant for Stryker and Salient.*

*Correspondence should be addressed to: Ronak M. Patel, MD, Department of Orthopaedic Surgery, Feinberg School of Medicine, Northwestern University, 401 E Ontario St, Unit #1707, Chicago, IL 60611 (r-patel7@md.northwestern.edu).*

*doi: 10.3928/01477447-20120426-16*

Joint reconstruction remains a successful and popular surgery, with continuous advances in approaches, implants, and techniques. With pressure placed on surgeons to increase efficiency and reduce the length of hospital stays, patients are mobilized quickly postoperatively.<sup>1</sup> Stress on wounds from early mobilization and accelerated rehabilitation programs highlights the importance of skin closure.<sup>2,3</sup> Skin closure techniques should minimize wound dehiscence and infection while promoting healthy, rapid healing and acceptable cosmesis. Complications from stitch abscesses to deep infections requiring revision surgery can disrupt patient recovery, increase hospital stays and costs, and cause patient morbidity.

Various methods of skin closure exist to address issues in efficiency, aesthetics, and barrier to infection. Staples and nylon sutures are 2 of the most commonly used skin closure materials in joint reconstruction surgery. Buried and nonburied techniques have also been applied to attempt to improve cosmesis. Although subcuticular skin closure techniques offer an aesthetic advantage over conventional skin stapling, no measurable differences have been reported.<sup>4</sup> Furthermore, newer barbed sutures, such as the V-Loc absorbable suture (Covidien, Mansfield, Massachusetts), theoretically distribute tension evenly through the wound and help decrease knot-related complications (Figure).<sup>5</sup> Studies using barbed sutures in nonorthopedic surgeries report decreased time to achieve closure and less dependency on the operator expertise necessary to secure a knot.<sup>5-7</sup> However, none of these wound closures involved underlying prosthetic implants, as is the case in joint reconstructive surgery.

To the authors' knowledge, the rate of wound complications in joint arthroplasty with the use of V-Loc suture for skin closure has not been reported. Therefore, the authors asked whether wound complication rates were (1) lower in V-Loc closure cases as theoretically suggested, (2) lower for subcuticular closure vs staples, and (3)

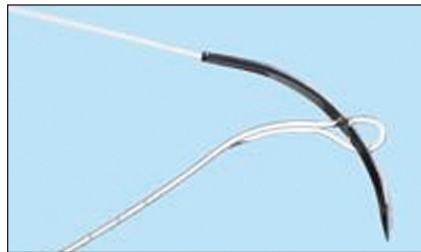


Figure: Image of V-Loc barbed suture with unidirectional barbs.

significantly different for knee and hip joint reconstruction.

**MATERIALS AND METHODS**

After receiving Institutional Review Board approval, the records of patients who underwent surgery by a single fellowship-trained adult reconstruction surgeon (L.P.) at a single institution between July 1, 2009, and June 30, 2010, were identified. All cases other than joint reconstruction cases were excluded, leaving 315 consecutive cases. Of these, 37 cases were revision surgeries and were excluded. Ultimately, a retrospective review of 278 consecutive primary joint reconstruction cases was conducted. No cases were excluded based on preoperative diagnosis, patient demographics, or patient age. Preoperative history and physical records were evaluated for comorbidities (eg, diabetes mellitus), medications (eg, steroids), smoking status, and body mass index. Operative reports dictated by the attending surgeon provided information on the surgical procedure, use of a drain, wound closure technique, type of suture/staple used for skin closure, and intraoperative wound complications. Postoperative hospital progress notes and clinic follow-up notes were reviewed to identify indicators of postoperative complications (eg, wound characteristics, persistent drainage, antibiotic usage, clinic procedures, and revision surgery) within 30 days of the index surgery.

The study group comprised 106 men and 161 women. Average patient age at surgery was 63 years (range, 18-92 years), and

Table 1

**Primary Joint Reconstruction Cases**

Reconstruction Type	No.
Hip	
Primary THA	121
Hemiarthroplasty	4
Knee	
Primary TKA	150
Bilateral TKA	11
Unicompartmental arthroplasty	3
Patellofemoral arthroplasty	1

Abbreviations: THA, total hip arthroplasty; TKA, total knee arthroplasty.

average body mass index of the cohort was 33.7 kg/m<sup>2</sup> (range, 25-51 kg/m<sup>2</sup>).

**SURGICAL TECHNIQUE**

Overall, 153 procedures were at the knee (including total knee arthroplasty, unicompartmental arthroplasty, and patellofemoral arthroplasty), and 125 procedures were at the hip (including total hip arthroplasty and hemiarthroplasty) (Table 1). All knee procedures involved a less-invasive midline incision (average, 4-6 inches) with a medial parapatellar arthrotomy and included placement of a hemovac suction drain that exited the skin at a remote site and was removed at bedside on postoperative day 1. All knee procedures, except patellofemoral arthroplasty, were performed with computer-assisted navigation, and all trackers were placed within the primary surgery wound. All hip procedures involved a less-invasive posterolateral approach with a skin incision that averaged 4 to 6 inches depending on the patient size and difficulty of the procedure. Hip procedures were performed with navigation or placement of drains.

Wound closure was completed simultaneously by the surgeon (L.P.) and his chief resident. In hips, the capsule and external

rotators were repaired to the greater trochanter, followed by a closure of the fascia with interrupted figure-of-eight 1-0 Vicryl suture (Ethicon, Inc, Somerville, New Jersey). The subcutaneous tissue was closed with 2-0 simple interrupted Vicryl stitches. The knee fascia and subcutaneous tissue were closed in a similar sequential manner, with the knee in 30° of flexion (including skin). Skin was consecutively closed with a staple gun with metal staples for the first 7 months of the study period, for a total of 160 cases. Surgeon preference changed to a subcuticular closure in February 2010, and 51 consecutive cases were closed with a 3-0 monofilament Biosyn absorbable suture (Covidien). The surgeon subsequently switched to the 3-0 V-Loc subcuticular stitch for 46 consecutive cases. Staples served as the original preferred method of skin closure. The surgeon applied subcuticular suture closure for consecutive cases (first Biosyn, then V-Loc) until increased concern for wound complications led the surgeon to revert to staple skin closure for the final 21 cases.

The Biosyn and V-Loc sutures are composed of glycolide, dioxanone, and trimethylene carbonate to form an absorbable compound. Average duration until absorption is 90 days. The V-Loc contains unidirectional barbs that project from the longitudinal axis of the suture. The surgical skin stapler (Covidien) held stainless steel staples.

The wounds closed with a subcuticular suture then had Mastisol (Eloquest Healthcare, Ferndale, Michigan) and adhesive skin closure strips applied superficially. The staples group had no adhesive skin closure strips. All wounds were then dressed with sterile Xeroform dressing (Covidien), gauze, ABD pads, and cast padding.

Original operating room dressings were changed on postoperative day 2. Drains were removed on postoperative day 1 in patients undergoing total hip arthroplasty. The surgeon's standard anticoagulation protocol included nightly warfarin starting the day of surgery, with a goal of reaching a therapeutic international normalized ratio of 2.0 to

3.0 for 4 weeks. The dosage of warfarin was managed by pharmacists in the anticoagulation dosing service at the hospital. Patients undergoing total knee arthroplasty, but not those undergoing total hip arthroplasty, received prophylactic dose low-molecular-weight heparin on postoperative day 1 as a bridge until international normalized ratio levels were therapeutic.

Patients returned to the clinic approximately 2 weeks postoperatively for routine clinical follow-up, including wound inspection. Subsequent outpatient follow-up consisting of clinical and radiographic evaluation occurred at 4 and 8 weeks postoperatively.

Results were analyzed by Pearson's chi-square test for equality of 2 independent proportions to determine whether the incidence of complications had achieved a statistically significant difference. For all analyses, a statistical confidence level of 95% was used. Post-hoc analysis indicated that our study population provided sufficient power to delineate, with significance at the  $\alpha=0.05$  level, differential complication rates of >6% for staple vs suture contrasts, >7% for staple vs V-Loc contrasts, >6% for staple vs Biosyn contrasts, and >14% for Biosyn vs V-Loc contrasts. The Wilson/Ghosh method was used to formulate 2-sided confidence intervals for complication rates, which accounts for the statistical complication inherent in generating confidence intervals for small binomial distributions. Data analysis was conducted using SPSS version 19.0 software (SPSS, Inc, Chicago, Illinois) and the R software platform (R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

In the review of 278 consecutive cases of primary joint reconstruction, 17 postoperative wound complications occurred, including cellulitis, stitch abscesses, wound dehiscence, and deeper infections requiring irrigation and debridement (Table 2). Seven (3.9%) wound complications occurred in 181 cases closed with staples. Ten

(10.3%) wound complications occurred in 94 cases closed via subcuticular absorbable suture: 4 (7.8%) in 51 cases closed via subcuticular Biosyn suture and 6 (13.0%) in 46 cases closed with V-Loc suture. Thus, a higher complication rate occurred in the suture group compared with the staple group ( $P=.033$ ). Furthermore, a difference in complication rate existed between the staple group and the V-Loc suture group ( $P=.017$ ). Although a trend existed toward decreased incidence of complications in staples compared with Biosyn, statistical significance was not achieved ( $P=.24$ ). Similarly, no statistical significance was found when comparing Biosyn suture with V-Loc suture ( $P=.40$ ).

Five (29.4%) of the 17 complications occurred in patients who were active smokers; 3 were closed with staples and 2 with subcuticular Biosyn closure. Average body mass index of the patients who experienced complications was 32.9 kg/m<sup>2</sup> (range, 26-42 kg/m<sup>2</sup>); the average of the entire cohort was 33.7 kg/m<sup>2</sup>.

When classifying wound complications as minor or major, where major complications required surgical intervention, 6 complications were major. Two (1.1%) major wound complications occurred in 181 skin closures completed with staples, and 4 (4.2%) major wound complications occurred in 96 cases closed via subcuticular absorbable suture. Of those 4 complications, 2 (4.3%) occurred in cases closed with V-Loc suture. Half (3/6) of all major complications occurred in active smokers. Average body mass index of patients who experienced major complications was 35.2 kg/m<sup>2</sup> (range, 29-42 kg/m<sup>2</sup>); the average of the entire cohort was 33.7 kg/m<sup>2</sup>.

In comparing both major and minor complications with only major complications, both groups showed a higher incidence of wound complications with subcuticular absorbable suture skin closure compared with skin closed with metal staples. More complications occurred in the V-Loc group compared with the Biosyn group; however, given the small proportions in-

Table 2

Complications Based on Closure Technique

Patient Sex/Age, y	Joint	Procedure	Closure Technique	Comorbidity	Smoking Status	BMI, kg/m <sup>2</sup>	Complication	Treatment
F/53	Knee	TKA	Staples	Rheumatoid arthritis	Y	34	Superficial infection	I&D
M/74	Knee	TKA	Staples	None	N	38	Hematoma	Observation
M/58	Knee	TKA	Staples	None	N	27	Cellulitis	Oral antibiotics
M/53	Knee	TKA	Staples	None	N	36	Stitch abscess	Oral antibiotics
M/82	Knee	TKA	Staples	None	N	27	Stitch abscess	Oral antibiotics
F/30	Hip	THA	Staples	Avascular necrosis	Y	29	Cellulitis	Oral antibiotics
M/64	Knee	TKA	Staples	None	N	38	Wound infection	I&D, polyethylene exchange
M/67	Knee	TKA	Subcuticular: Biosyn <sup>a</sup>	Posttraumatic arthritis	Y	29	Wound dehiscence, infection	I&D and closure
M/70	Knee	TKA	Subcuticular: V-Loc <sup>a</sup>	None	N	36	Thigh hematoma	Observation
M/72	Hip	THA	Subcuticular: V-Loc	None	N	39	Wound dehiscence	I&D and closure
F/79	Knee	TKA	Subcuticular: V-Loc	None	N	42	Wound infection	I&D, polyethylene exchange
F/60	Knee	TKA	Subcuticular: V-Loc	Rheumatoid arthritis	N	40	Stitch abscess	Bedside exploration
M/62	Knee	TKA	Subcuticular: V-Loc	None	N	28	Stitch abscess	Bedside exploration
F/63	Hip	THA	Subcuticular: V-Loc	None	N	26	Superficial wound opening	Sterile suture reinforcement at bedside
M/71	Knee	TKA	Subcuticular: Biosyn	None	N	31	Cellulitis	Oral antibiotics
F/28	Hip	THA	Subcuticular: Biosyn	Avascular necrosis, diabetes mellitus type II, SLE with chronic steroid use	Y	29	Hematoma/wound infection	I&D, polyethylene exchange
F/56	Knee	TKA	Subcuticular: Biosyn	None	N	30	Cellulitis	Oral antibiotics

Abbreviations: BMI, body mass index; I&D, irrigation and debridement; N, no; SLE, systemic lupus erythematosus; THA, total hip arthroplasty; TKA, total knee arthroplasty; Y, yes.  
<sup>a</sup>Covidien, Mansfield, Massachusetts.

involved, statistical significance was not achieved. To demonstrate these trends, the confidence intervals are displayed in Table 3. For the confidence intervals, the relevant interval used is 90% because comparing 2 proportions (the lower bound of one to the upper bound of another) is a 1-sided test for equality of the 2 proportions at the 95% confidence level.

When looking at all complications by joint (ie, hip vs knee), a higher trend of complications existed in knees compared with hips for all methods of skin closure (Table 4). Regardless of joint, the complication rate was highest for V-Loc suture, followed by Biosyn suture and, lastly, staples. Again, given the small proportions, statistical significance was not achieved.

DISCUSSION

The purpose of this study was to report our experience with the V-Loc barbed suture for skin closure in joint reconstruction, as well as overall subcuticular suture skin closure compared with that of metal staples. Changes in skin closure technique are secondary to multiple factors, including surgeon preference, patient marketabil-

ity, hospital standards, and wound tension. Theoretical advantages of a barbed suture include distribution of tension throughout the wound, decreased knot-related complications, and faster application.<sup>5-8</sup>

A randomized equivalency study of 188 patients evaluated bidirectional barbed suture vs conventional polydioxanone suture for dermal closure of Pfannenstiel incisions in gynecologic cases and reported similar cosmesis, infection, and dehiscence scores and comparable pain scores and closure time.<sup>5</sup> Reports of decreased adverse events associated with the use of barbed suture are based on studies performed in minimally invasive facelift surgery.<sup>9,10</sup> An explanation for this difference in outcomes may be secondary to the relationship of the barb stiffness and direction with the native soft tissue.<sup>11,12</sup> The current study's results in orthopedic joint reconstruction demonstrate similar incidences of major wound complications in the conventional subcuticular suture and V-Loc suture groups. However, an increased rate of minor complications occurred with the V-Loc suture. Potentially, the tightness and water-tight seal provided by the V-Loc suture is less forgiving than a conventional suture to the high stresses of postoperative mobilization and normal physiologic drainage after joint replacement. Given the same material composition of V-Loc and Biosyn sutures (glycolide, dioxanone, and trimethylene carbonate), the difference in complications is unlikely to be attributable to a biologic response. Moreover, the authors are unaware of any studies comparing biological and histological soft tissue responses to stainless steel staples with those to absorbable suture in skin closure.

The current study found a statistically significant higher rate of complications in the V-Loc group compared with the staple group. Whether staples or sutures lead to lower rates of wound inflammation is controversial, perhaps dependent on the location of the wound on the body.<sup>2,13-16</sup> Graham et al<sup>17</sup> reported that staple closure resulted in better blood perfusion to wound sites

Table 3

Confidence Intervals of Major Complications by Closure Technique				
90% CI	Staple	Suture <sup>a</sup>	V-Loc <sup>b</sup>	Biosyn <sup>b</sup>
Upper limit	0.0698	0.1701	0.2377	0.1699
Lower limit	0.0211	0.0647	0.0705	0.0372

*Abbreviation: CI, confidence interval.*  
<sup>a</sup>Aggregate.  
<sup>b</sup>Covidien, Mansfield, Massachusetts.

Table 4

Variable	No. (%)							
	Major Complications				All Complications (Major+Minor)			
	Staples	Biosyn <sup>a</sup>	V-Loc <sup>a</sup>	Total	Staples	Biosyn	V-Loc	Total
Male	1/76 (1.3)	1/20 (5)	1/13 (7.7)	3/109 (2.8)	5/76 (6.6)	2/20 (10)	3/13 (23)	10/109 (9.2)
Female	1/105 (1)	1/31 (3.2)	1/33 (3.0)	3/169 (1.8)	2/105 (2)	2/31 (6.5)	3/33 (9.1)	7/169 (4.1)
Hip	0/81 (0)	1/21 (4.8)	1/23 (4.3)	2/125 (1.6)	1/81 (1.2)	1/21 (4.8)	2/23 (8.7)	4/125 (3.2)
Knee	2/100 (2.0)	1/30 (3.3)	1/23 (4.3)	4/153 (2.6)	6/100 (6.0)	3/30 (10)	4/23 (17.3)	13/153 (8.5)

<sup>a</sup>Covidien, Mansfield, Massachusetts.

compared with suture closure. Increased blood perfusion and decreased disruption of the wound site could enhance healing. Further investigation is needed on soft tissue disruption in V-Loc sutures, particularly compared with skin staples.

Although the V-Loc suture represents a relatively recent advance and subject of research, multiple studies have evaluated suture vs staple closure in joint arthroplasty.<sup>1,2,18</sup> However, debate exists on which is the optimal method of closure. Khan et al<sup>2</sup> investigated skin closure in joint arthroplasty and reported that skin staples were superior to subcuticular suture. They concluded that staple closure was faster than suture closure, with no difference in complication rate, patient satisfaction, or cosmesis.<sup>2</sup> A recent meta-analysis by Smith et al<sup>1</sup> reported that staples were associated with a higher rate of infection in hip surgery compared

with suture closure. The meta-analysis included all orthopedic procedures of the hip and knee and did not differentiate between superficial and deep infections—intrinsic limitations to that type of study.<sup>1</sup> The current study's results showed decreased rates of major and minor complications in the staple group compared with the subcuticular suture group.

The overall complication rate in the current study was higher in knees than in hips, but given the small proportions, no statistical significance was achieved. Khan et al<sup>2</sup> attributed this to the fact that incisions at the knee are longer than those at the hip and that the skin at the knee is more mobile than that at the hip. They reported no statistically significant difference in their late complication rate (hip, 14.7%; knee, 18.8%).<sup>2</sup>

The current study did not measure cosmetic outcomes, pain scores, or closure



time. Furthermore, although cost can be a driving force for many surgeons and institutions, the authors did not include that in their analysis. The literature reports that metal staples are more expensive than conventional suture; however, the authors of the current study we found no comparison with V-Loc suture.<sup>1,2,19</sup> Although a consecutive series, the current study faces the intrinsic limitations of a retrospective analysis, including data collection limited to medical records. Also, not all factors related to wound healing could be accounted for, including nutrition, amount of drainage, and hygiene. However, the authors of the current study analyzed 2 known risk factors for wound complications, particularly in orthopedic surgery: obesity and smoking.<sup>20-22</sup> Patients with these risk factors deserve special attention with regard to wound closure and may benefit from a skin closure associated with fewer surgical-site complications.

Another limitation of the current study is the power. A significantly larger number of patients made up the staple cohort than the conventional suture and V-Loc suture cohorts. However, the limited number of skin closures by subcuticular means was secondary to the surgeon's heightened concern for wound complications. Although subcuticular suture closure may require more technical skill than staple placement, the authors do not believe a learning curve would occur, given the seniority and experience of the surgeon. Lastly, all complications in this study may not be directly attributed to skin closure method, indicating the need for further randomized, prospective trials.

The incidence of wound complications in surgical joint reconstruction ranges from 0.33% to 50%, with the mode deviating toward the lesser number.<sup>23-25</sup> The complication rate in the current study varied depending on the type of skin closure used. Early surgical intervention for total knee arthroplasty wound healing has been associated with further complications, including deep infections, resection arthroplasty,

and flap coverage.<sup>26</sup> Wound complications in patients undergoing joint reconstruction can cause myriad problems and should be minimized by all means available.

### CONCLUSION

Aesthetics and efficiency often are the driving forces of innovation. Based on the authors' clinical experience, wound and infectious complications should be considered when choosing a method of skin closure in joint reconstruction procedures. ■

### REFERENCES

1. Smith TO, Sexton D, Mann C, et al. Sutures versus staples for skin closure in orthopaedic surgery: meta-analysis. *BMJ*. 2010; 340:c1199.
2. Khan RJ, Fick D, Yao F, 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):238-242.
3. Dowsey MM, Kilgour ML, Santamaria NM, et al. Clinical pathways in hip and knee arthroplasty: a prospective randomised controlled study. *Med J Aust*. 1999; 170(2):59-62.
4. Obermair A, Crandon A, Perrin L, et al. Randomized trial of skin closure after laparotomy for gynaecological surgery. *ANZ J Surg*. 2007; 77(6):460-463.
5. Murtha AP, Kaplan AL, Paglia MJ, et al. Evaluation of a novel technique for wound closure using a barbed suture. *Plast Reconstr Surg*. 2006; 117(6):1769-1780.
6. Demyttenaere SV, Nau P, Henn M, et al. Barbed suture for gastrointestinal closure: a randomized control trial. *Surg Innov*. 2009; 16(3):237-242.
7. Singer AJ, Hollander JE, Valentine SM, et al. Association of training level and short-term cosmetic appearance of repaired lacerations. *Acad Emerg Med*. 1996; 3(4):378-383.
8. Vakili JJ, O'Reilly MP, Sutter EG, Mears SC, Belkoff SM, Khanuja HS. Knee arthroscopy repair with a continuous barbed suture: a biomechanical study [published online ahead of print September 3, 2010]. *J Arthroplasty*. 2011; 26(5):710-713.
9. Villa MT, White LE, Alam M, et al. Barbed sutures: a review of the literature. *Plast Reconstr Surg*. 2008; 121(3):102e-108e.
10. Shermak MA, Mallalieu J, Chang D. Barbed suture impact on wound closure in body contouring surgery. *Plast Reconstr Surg*. 2010; 126(5):1735-1741.
11. Ingle NP, King MW. Optimizing the tissue anchoring performance of barbed sutures in

12. Ingle NP, King MW, Zikry MA. Finite element analysis of barbed sutures in skin and tendon tissues. *J Biomech*. 2010; 43(2):302-309.
13. Newman JT, Morgan SJ, Resende GV, et al. Modality of wound closure after total knee replacement: are staples as safe as sutures? A retrospective study of 181 patients. *Patient Saf Surg*. 2011; 5(1):26.
14. Chughtai T, Chen LQ, Salasidis G, et al. Clips versus suture technique: is there a difference? *Can J Cardiol*. 2000; 16(11):1403-1407.
15. Trick WE, Scheckler WE, Tokars JI, et al. Modifiable risk factors associated with deep sternal site infection after coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 2000; 119(1):108-114.
16. Clayer M, Southwood RT. Comparative study of skin closure in hip surgery. *Aust N Z J Surg*. 1991; 61(5):363-365.
17. Graham DA, Jeffery JA, Bain D, et al. Staple vs. subcuticular vicryl skin closure in knee replacement surgery: a spectrophotographic assessment of wound characteristics. *Knee*. 2000; 7(4):239-243.
18. Shetty AA, Kumar VS, Morgan-Hough C, et al. 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)*. 2004; 12(2):191-193.
19. Livesey C, Wylde V, Descamps S, et al. Skin closure after total hip replacement: a randomised controlled trial of skin adhesive versus surgical staples. *J Bone Joint Surg Br*. 2009; 91(6):725-729.
20. Waisbren E, Rosen H, Bader AM, et al. Percent body fat and prediction of surgical site infection. *J Am Coll Surg*. 2010; 210(4):381-389.
21. Chaudhry S, Egol KA. Ankle injuries and fractures in the obese patient. *Orthop Clin North Am*. 2011; 42(1):45-53.
22. Moller AM, Pedersen T, Villebro N, et al. Effect of smoking on early complications after elective orthopaedic surgery. *J Bone Joint Surg Br*. 2003; 85(2):178-181.
23. Vince K, Chivas D, Droll KP. Wound complications after total knee arthroplasty. *J Arthroplasty*. 2007; 22(4 suppl 1):39-44.
24. Patel VP, Walsh M, Sehgal B, et al. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. *J Bone Joint Surg Am*. 2007; 89(1):33-38.
25. Jansen E, Huhtala H, Puolakka T, et al. Risk factors for infection after knee arthroplasty. A register-based analysis of 43,149 cases. *J Bone Joint Surg Am*. 2009; 91(1):38-47.
26. Galat DD, McGovern SC, Larson DR, et al. Surgical treatment of early wound complications following primary total knee arthroplasty. *J Bone Joint Surg Am*. 2009; 91(1):48-54.