STUDY TO DETERMINE THE BEST SURGICAL SKIN WOUND CLOSURE MATERIAL OUT OF NYLON, SILK OR STAPLE, FOR USE IN VARIOUS ORTHOPEDIC SURGICAL PROCEDURES

Abstract:

Background: In the spectrum of surgical decision-making, wound closure material is often an afterthought. Effective skin closure conducive to wound healing by primary intention is vital for the postoperative morbidity. Skin closure has proved elusive despite unceasing efforts for many millennia not only due to techniques but also because no ideal suture material has so far been found. From time to time in surgical literature, there have been discussion of the ideal suture material. Hence this study has been undertaken to compare three methods of wound closure (staples, silk, and nylon) and to find out if any one of these scores over others.

Materials and Methods: The present study was conducted in the Department of Orthopedics at Sri Guru Ram Das Institute of Medical Sciences and Research, Vallah, Sri Amritsar. This study included 90 patients (57 men and 33 women; age >18yrs.), undergoing orthopedic surgical procedures in whom, surgical wound closure was done either by skin suture (nylon or silk) or skin staples, during the period from Dec 2014 to August 2016. Prior ethical approval from Institutional Ethical Committee was obtained. Patients with Open fracture, Known nickel allergy, Active infection (any site), Chemotherapy during study period (1 month prior until end of follow-up), Radiation therapy to surgical site (1 month prior until end of follow-up), Foot surgery (any site), Hand surgery (including carpal surgery), Revision surgery or with a previous incision in the operative field, and with History of keloid formation were excluded from the study. All the consenting patients were randomized into three groups with respect to the type of wound closure material. The three methods of closure were Staples (Group A), Silk (Group B), Nylon (Group C).

Results and Conclusions: We observed that the mean age of patients in staple group was 54.43 years, in silk group was 36.53 years and in nylon group was 39.63 years. The difference in the mean asepsis score among the three group was statistically not significant (p value 0.356). In both groups (nylon as well as staple group), 10%(three patients) had disturbance of healing while 3.33%(one patient) of the patients had minor infection. But no patient in the silk group had any wound healing problems.

Key words: Wound closure, Nylon, Silk, Staple, Orthopedic surgical Procedures
Introduction:

In the spectrum of surgical decision-making, wound closure material is often an afterthought. With pressure placed on surgeons to increase efficiency and reduce the length of hospital stay, patients are mobilized quickly postoperatively. Stress on wounds from early mobilization and accelerated rehabilitation programs highlights the importance of skin closure. Effective skin closure conducive to wound healing by primary intention is vital for the postoperative morbidity. Skin closure has proved elusive despite unceasing efforts for many millennia not only due to techniques but also because no ideal suture material has so far been found. From time to time in surgical literature, there have been discussion of the ideal suture material.

A wide choice of suture materials is available to surgeons today. The choice of suture for a particular procedure should be based on the known physical and biological properties of the suture material, suturing technique and the healing properties of the sutured tissues. However, the availability of the suture material and the personal preference of the surgeon play important roles.

Sutures available today are classified as permanent or absorbable, natural or synthetic, and multifilament or monofilament. Multifilament or braided sutures are easy to handle and have favorable knot-tying qualities. However, bacteria can enter the braided interstices and escape phagocytosis, potentially leading to suture infection, granulomas and sinuses. By contrast, monofilament sutures cause significantly fewer tissue reactions and glide easily through tissue. Their disadvantages include high retention of package shape, difficult handling, knot insecurity, and potentially cutting through tissue.

In orthopedics surgery, the most common skin closure methods are the use of staples or sutures. 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.

In practice, it is uncommon for a patient to receive the choice of closure method pre-operatively and it is also rare to find patients with absolute preferences to one closure material over another. Hence this study has been undertaken to compare three methods of wound closure (staples, silk, nylon) and to find out if any one of these scores over others.

Material And Methods:

Research Setting and Participants:
The present study was conducted in the Department of Orthopedics at Sri Guru Ram Das Institute of Medical Sciences and Research, Vallah, Sri Amritsar. This study included 90 patients (57 men and 33 women; age >18yrs.), undergoing orthopedic surgical procedures in whom, surgical wound closure was done either by skin suture (nylon or silk) or skin staples, during the period from Dec 2014 to August 2016. Prior ethical approval from Institutional Ethical Committee was obtained. Patients with history of diabetes, peripheral vascular disease, renal failure requiring dialysis, liver failure and inflammatory arthritis were identified. Medications including corticosteroids, transplant anti-rejection medications, disease-modifying anti-rheumatic drugs warfarin, aspirin, clopidogrel and heparin were noted by patient report. A smoking history was also obtained. All cases were clean and surgeries performed in a dedicated orthopedic clean-air theatre. Usual preparation of skin with antiseptics and steridrapes was used in all patients.

The same pre and post-operative protocol of care was applied to all patients including per-operative antibiotic cover and thromboprophylaxis, during their inpatient stay. The deep tissues were closed in a standard manner using vycril no. 1 for the deep fascia and subcutaneous tissue, in order to remove skin tension and align the wound edges.

Wound dressing were changed on second post-operative day and signs of surgical site infection were looked for. Subsequent dressings were done depending upon the presence or absence of wound soakage. If an infection was noted, discharge was sent for culture and sensitivity testing. Sutures were removed twelve days after surgery.

Outcome measure: The outcome measure was a composite outcome encompassing all causes of wound
complication. The components consist of the following events:

1. Surgical site infection as defined by:
   - At least one of the following signs or symptoms of infection - pain or tenderness, localized swelling, redness or local rise of temperature.
   - Purulent drainage from the incision.
   - Organisms isolated from an aseptically obtained culture of fluid or tissue from the incision.
   - Stitch abscesses (minimal inflammation and discharge confined to the points of suture penetration).
   All wounds discharging after the third day were swabbed for microbiological culture. Wounds with persistent ooze after the fourth post-operative day, but with negative cultures, were recorded as having 'prolonged discharge'.

2. Wound drainage occurring after post-operative day two requiring a dressing change.

3. Wound Necrosis defined as blackening of the skin edges at the incision site or skin slough.

4. Per-incision Blistering defined as blistering at the edge of the incision along the entire length. Blistering at dressing tape site will be excluded from this definition, however, blistering due to wound tape application which is contiguous with the wound edge will be considered an event.

5. Wound Dehiscence as defined by the loss of apposition of the skin edges visible to the eye along the length of the incision.

6. Material Sensitivity as defined by a local reaction to metal or suture material resulting in skin changes along the entire incision length.

7. Total Duration of hospital stay and the post op day of suture removal along with any discomfort during suture removal was recorded.

8. Cosmetic appearance was assessed using Wound Evaluation Scale.20

9. Wound evaluation score based on ASEPSIS score.21,22

Points scale used to calculate total ASEPSIS score

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Points</th>
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<tbody>
<tr>
<td>Additional treatment</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td>10</td>
</tr>
<tr>
<td>Drainage of pus under local anaesthetic</td>
<td>5</td>
</tr>
<tr>
<td>Debridement of wound under general anaesthetic</td>
<td>10</td>
</tr>
<tr>
<td>Serous discharge</td>
<td>0 to 5</td>
</tr>
<tr>
<td>Erythema</td>
<td>0 to 5</td>
</tr>
<tr>
<td>Purulent exudate</td>
<td>0 to 10</td>
</tr>
<tr>
<td>Separation of deep tissues</td>
<td>0 to 10</td>
</tr>
<tr>
<td>Isolation of bacteria</td>
<td>10</td>
</tr>
<tr>
<td>Stay in hospital over 14 days</td>
<td>5</td>
</tr>
</tbody>
</table>

Proportion of wound affected (%)

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1-19</th>
<th>20-39</th>
<th>40-59</th>
<th>60-79</th>
<th>80-100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serous Exudates</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Erythema</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Purulent Exudates</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Separation of deep tissues</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
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</table>

Breakdown of ASEPSIS scores

<table>
<thead>
<tr>
<th>Score</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>0 to 10</td>
<td>Satisfactory healing</td>
</tr>
<tr>
<td>11 to 20</td>
<td>Disturbance of healing</td>
</tr>
<tr>
<td>21 to 30</td>
<td>Minor infections</td>
</tr>
<tr>
<td>31 to 40</td>
<td>Moderate infection</td>
</tr>
<tr>
<td>≥ 41</td>
<td>Severe infection</td>
</tr>
</tbody>
</table>

Hollander Wound Evaluation Score (HWES) :

- a. Step off borders (0 for yes, 1 for no)
- b. Contour irregularity-puckering
- c. Scar width-greater than 2 mm
- d. Edge inversion-sinking, curling
- e. Inflammation-redness, discharge
- f. Overall cosmesis (0 = poor, 1 = acceptable)

Each of these categories is graded on a 0-or-1-point scale. A total cosmetic score is derived by the addition of the scores of the 6 categorical variables. A score of 6 is considered optimal, while a score of < 5 suboptimal

Research Design: This study was a prospective randomized study.

Statistical analysis: All the statistical analyses were performed on Statistical Package for Social Sciences (SPSS-version 17.0) for Windows. Proportion, one way ANOVA and Pearson Chi square test (continuity correction) were used to examine the significance of association (contingency). It was referenced for two-tailed P value and 95% confidence interval was constructed around sensitivity proportions using normal
approximation method. A value of <0.05 was assumed to attain sufficient statistical significance.

Figure 1: Non capillary silk has excellent handling and tying characteristics

Figure 2: Monofilament nylon is a polyamide suture with high tensile strength

Figure 3: Skin stapler

Observations And Results:

All the consenting patients were randomized into three groups with respect to the type of wound closure material.

Table 1: Number of cases

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of patients</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Group A – (staple group) 30</td>
</tr>
<tr>
<td>2</td>
<td>Group B – (silk group) 30</td>
</tr>
<tr>
<td>3</td>
<td>Group C – (nylon group) 30</td>
</tr>
</tbody>
</table>

Types of Surgical procedure done:

Fifty three patients out of ninety had open reduction and internal fixation with plating. Four patients out of ninety underwent open reduction and internal fixation with tension band wiring. Four patients underwent closed reduction and internal fixation with cannulated screws. Sixteen patients underwent total hip replacement while total knee replacement was done in thirteen patients.

Cosmetic appearance:

Patients in the three groups were followed up one month post surgery. The wound was assessed for cosmesis using modified Hollander cosmesis scale which has six clinical variables as step-off borders, edge inversion, contour irregularities, excess inflammation, wound margin separation, and good overall appearance. A total cosmetic score was derived by adding the scores of variables. A score of one was given to each variable if not present in the wound, so a score of six was considered as optimal while five or less as sub-optimal. The mean cosmesis score in nylon group was 5.00, in silk group was 5.40 and in staple group was 5.20. The difference in the mean cosmetic score among the three groups was statistically not significant (p value 0.482).

<table>
<thead>
<tr>
<th>Cosmetic Wound score</th>
<th>Nylon</th>
<th>Silk</th>
<th>Staples</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suboptimal (&lt;6)</td>
<td>13 (43.3%)</td>
<td>9 (30%)</td>
<td>13 (43.3%)</td>
<td>35</td>
</tr>
<tr>
<td>Optimal (=6)</td>
<td>17 (56.7%)</td>
<td>21 (70%)</td>
<td>17 (56.7%)</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
</tr>
</tbody>
</table>
Wound complications:

Wound complications were calculated on the basis of asepsis score

![Graph showing mean asepsis score for nylon, silk, and staple closures.]

Two patients further had a minor infection; one had his wound closed with nylon while the other wound was closed with staples. A total of sixteen patients underwent total hip replacement. Only two patients among these reported a disturbance of healing. Both the patient had their wound closed with staples.

Image 1 & 2: Forearm wound closure with silk postoperative day one and thirty, respectively.

Image 3 & 4: THA wound postoperative day five and day twelve respectively.

Image 5: TKA wound in another patient postoperative day thirty.
Image 6 & 7: Both bone forearm fracture ORIF with plating done, wound closed with nylon shows slight gapping and perincisional blackening.

Image 8 & 9: Same patient at one month follow up.

Image 10: Sinus formation in a patient with humerus fracture ORIF with plating done closed with nylon suture. Debridement of the wound was done, the sinus was found to be superficial to the deep fascia.

Image 11: Humeral shaft fracture patient ORIF with plating done wound was closed with nylon, signs of superficial infection was seen which was resolved with antibiotics.

Image 18: Distal femur plating wound closed with staples.

Discussion:

Orthopedic surgeons are continually seeking approaches to provide robust wound closure required for rapid rehabilitation while simultaneously reducing operating room (OR) procedure time and cost, especially in the era of cost containment. The preferred technique for wound closure would be time efficient, inexpensive, durable, nondehiscent, microbial resistant, and cosmetically pleasing. The incidence of wound complications after orthopedic surgery is not well defined. However, the impact of non-infectious complications has not yet been well defined.

In the present study the mean age of patients in staple group was 54.43 years, in silk group was 36.53 years and in nylon group was 39.63 years. In a study conducted by Shetty et al there were forty seven patients in suture and fifty four patients in staple group. The average age in suture group was 81.7 years and in staple group was 83.5 years.

Various procedures performed in our study ranged from open reduction internal fixation with plating, tension band wiring, cannulated screw fixation, total knee arthroplasty and total hip replacement. A total of eight patients developed wound complications as per asepsis score, out of which six patients had plating. Two patients under went total hip replacement and both had their wounds closed with staples. Among the six patients in the plating group which developed complications four had their wound closed with nylon and two had their wound closed with staples. The mean asepsis score in the nylon group was 6.0, in the silk group it was 2.33 while in the staple group it was 5.93. The difference in the mean asepsis score among the three groups
was statistically not significant (p value 0.356).

Regarding orthopedic procedure related skin closure; it would be prudent to base the use of sutures or staples on the anatomic location and the indication for the operation.

Murphy et al found no statistically significant difference in wound healing and cosmesis between the clip and suture groups of patients at follow-up. Clip removal with the special clip remover was found to be quicker and less painful (p=0.001). There was good patient satisfaction with the use of skin clips over nylon sutures.

It has been reported that staple use provides better blood perfusion to the wound sight than sutures, which was correlated to improved conditions for wound healing. It is possible that in areas with an abundant blood supply and adequate soft tissues, like the hip, that closure method may be irrelevant. In the soft tissues surrounding areas with less soft tissues or increased skin tension there may be a greater degree of vascular compromise based on wound closure technique. Biologically friendly closure techniques may prevent per-operative wound problems in anatomic regions where there are more restrictions on local resources.

Khan et al found that the overall rate of early complication for the groups in both the THR and TKR was similar. However, there was a notable difference in the early complication rates between the hip (5.9%) and the knee (17.6%). This was not surprising given that the knee wounds were significantly longer than those at hip and the increased mobility of the skin around the knee. Johnson et al and Stillman et al suggested that skin stapling might cause less damage to the wound’s defenses than non-absorbable sutures. This was based on the principle that the presence of a foreign material might compromise the immune response. Analysis of cost showed that although the use of clips was more expensive, the difference in real terms was not as great as may be assumed.

TO Smith suggested that the wounds closed with staples rather than sutures have four times the risk of infection. In addition, no information was available evaluating specific suture techniques, or surgeon skill. Murphy et al suggested that poor surgical technique and accuracy of suture or staple closure can have an effect on wound healing. However, it is unclear whether suturing technique is confounder with respect to postoperative wound complications.

A major limitation within the literature was that none of the studies differentiated between superficial and deep wound infections in their results. While superficial wound infections might be problematic for the patient, these will usually resolve with antibiotics. In contrast, a deep wound infection has a considerably greater impact, particularly in arthroplasty surgery, and requires extensive debridement, wound washout, prosthesis revision surgery, and, potentially, amputation.

The average duration of skin closure in nylon group was 10.37 minutes while in silk group it was 9.53 minutes and in staple group it was 6.27 minutes. Khan et al in 2006 found similar results after hip and knee replacements with both sutures and staples regarding complications and a significantly faster wound closure time when using staples. The relative discomfort of staple removal compared with suture removal has been previously cited in the non-orthopedic literature. Secondly, some authors have suggested that there might be greater satisfaction for surgeons in using staples than sutures. Recognizing the cost constraints of modern medicine, a trend toward decreased surgical time may have a significant impact on decreasing costs when factored over multiple procedures with consideration to the costs of operative time and anesthetic supplies.

Follow-up studies focusing on surgical time suggested that staples could save up to 80% of the time required for suturing with equal cosmetic results. Quicker wound closure times for orthopedic procedures involving extremity tourniquets helps to minimize total limb ischemia time and hence the reperfusion insult. In the modern operating room, staff and patients must be protected from communication of infectious diseases. The skin stapler is a more expensive technique for wound closure but if it prevents one potentially fatal needle stick injury, the expense is perhaps justified.

The average number of dressing changes in silk group were 5.20 while in nylon group were 5.73 where as it was 5.97 in staple group. The difference in the number of dressing changes was not significant (p value of 0.112). The use of staples has always been noted as a ‘more expensive method’ for skin closure as compared with using sutures. Using staples rather than Monocryl leads to increased rates of dressing changes for prolonged wound discharge. Dressing changes for prolonged wound discharge is a independent risk factor for adverse events. Patel et al (2007)-stated that prolonged wound drainage leads to higher infection rate (p<0.001)

Metal staples have been regarded as a more expensive option for wound
closure, though costs could be reduced by reduced theatre time and ease of clip removal compared with sutured wounds. This economy of suturing wounds might prove to be false, as the consequences of a deep infection for the patient are substantial through the increased costs associated with medical care and admission to hospital.¹⁶ Only Singh et al.¹⁷ assessed the cost effectiveness of the two methods of wound closure. They reported that the use of staples was three times more expensive than subcuticular vicryl sutures, when the staple applicator and remover were taken into account.¹⁸ The benefit of skin staples over nylon stitches was a decrease in operative time. However, they found skin staples to be more painful to remove as compared to nylon stitches. Stockley and Elson¹⁴ and Singh et al.¹⁷ reported that staples were invariably more painful to remove than sutures.

The importance of patient-centered outcomes is becoming more recognized in medicine. In orthopaedic surgery, the increasing popularity of patient-driven rather than surgeon-driven functional outcomes reflects this general trend. Little information exists on the incidence of patient-perceived wound complications in orthopaedic surgery. Based on the bias encountered in surgeon-measured outcomes there is a possibility that the current literature reflects an underestimate of the frequency of wound complications as a result of current definitions of these events and standard ways of determining their occurrence.³⁰

Conclusions:

The determination of the best surgical skin wound closure material out of nylon, silk or staple remains controversial, but we conclude silk as a better method of wound closure than staples or nylon. The surgeon’s preference and comfort with either method of wound closure should be combined with considerations of cosmetically good looking scar, operative time, convenience of the removal of wound closure material and patient preference for determining closure material for individual patients. Considering the small sample size of the present study as its limitation, it may not be very prudent to draw firm conclusions regarding the determination of best closure material. Probably, multicentric studies with larger sample size may help to find out the best closure material in orthopedic surgery.

Compliance With Ethical Standards

Conflict of interest: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical standards: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and all patients gave the informed consent prior being included into the study. This study was approved by the Research Ethics Committee (or Institutional Review Board)"