

## Sutures versus staples for skin closure in orthopaedic surgery: meta-analysis

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### ABSTRACT

**Objective** To compare the clinical outcomes of staples versus sutures in wound closure after orthopaedic surgery.

**Design** Meta-analysis.

**Data sources** Medline, CINAHL, AMED, Embase, Scopus, and the Cochrane Library databases were searched, in addition to the grey literature, in all languages from 1950 to September 2009. Additional studies were identified from cited references.

**Selection criteria** Two authors independently assessed papers for eligibility. Included studies were randomised and non-randomised controlled trials that compared the use of staples with suture material for wound closure after orthopaedic surgery procedures. All studies were included, and publications were not excluded because of poor methodological quality.

**Review methods** Two authors independently reviewed studies for methodological quality and extracted data from each paper. Final data for analysis were collated through consensus. The primary outcome measure was the assessment of superficial wound infection after wound closure with staples compared with sutures. Relative risk and mean difference with 95% confidence intervals were calculated and pooled with a random effects model. Heterogeneity was assessed with  $I^2$  and  $\chi^2$  statistical test.

**Results** Six papers, which included 683 wounds, were identified; 332 patients underwent suture closure and 351 staple closure. The risk of developing a superficial wound infection after orthopaedic procedures was over three times greater after staple closure than suture closure (relative risk 3.83, 95% confidence interval 1.38 to 10.68;  $P=0.01$ ). On subgroup analysis of hip surgery alone, the risk of developing a wound infection was four times greater after staple closure than suture closure (4.79, 1.24 to 18.47;  $P=0.02$ ). There was no significant difference between sutures and staples in the development of inflammation, discharge, dehiscence, necrosis, and allergic reaction. The included studies had several major methodological limitations, including the recruitment of small, underpowered cohorts, poorly randomising patients, and not blinding assessors to the

allocated methods of wound closure. Only one study had acceptable methodological quality.

**Conclusions** After orthopaedic surgery, there is a significantly higher risk of developing a wound infection when the wound is closed with staples rather than sutures. This risk is specifically greater in patients who undergo hip surgery. The use of staples for closing hip or knee surgery wounds after orthopaedic procedures cannot be recommended, though the evidence comes from studies with substantial methodological limitations. Though we advise orthopaedic surgeons to reconsider their use of staples for wound closure, definitive randomised trials are still needed to assess this research question.

### INTRODUCTION

With the development of accelerated rehabilitation and the pressures placed on surgeons to reduce lengths of stay in hospital, the method of skin closure has become increasingly important in orthopaedic surgery.<sup>1,2</sup> Wound complications are one of the major sources of morbidity after orthopaedic procedures and can prolong the inpatient stay or lead to re-admission.<sup>2</sup> The objective of good wound closure is rapid skin healing and an acceptable cosmetic result while minimising the risks of complications such as wound dehiscence or infection.<sup>3,4</sup> Such complications have a considerable impact on the recovery of the patient, causing increased morbidity, delayed discharge, increased costs, and reduced satisfaction.<sup>3,4</sup> There is also a link between superficial wound infection and deep (prosthetic) infection.<sup>5</sup>

The most commonly used methods for skin closure after orthopaedic surgery are metal staples or nylon sutures.<sup>1,3</sup> Both methods act to hold the skin edges together while healing occurs. Metal staples are said to be superior as they are regarded as quicker and easier than sutures.<sup>6-8</sup> Other authors have suggested that use of metal staples or clips has a greater risk of wound infection<sup>4</sup> and might be less acceptable cosmetically than sutures.<sup>2</sup> Metal staples might also be more expensive.<sup>2,9,10</sup>

Some authors have compared the clinical outcomes of wound closure with staples and sutures after

orthopaedic surgery. The optimal method of skin closure still remains unclear.<sup>211</sup> We reviewed the evidence base systematically and conducted a meta-analysis. We examined whether there is a difference in clinical outcomes with staples or sutures in orthopaedic wound closure in adult patients.

## METHODS

**Data sources**—We searched AMED (1985 to July 2009), British Nursing Index (1985 to July 2009), CINHAL (1982 to July 2009), Embase (1974 to July 2009), and Medline (1950 to July 2009) via Ovid. We also searched Scopus and the Cochrane Library. Details of the MeSH terms and keywords and the Boolean operators adopted can be found in the appendix on bmj.com. Unpublished literature was also assessed with the search terms “closure” AND “hip” from the databases SIGLE (System for Information on Grey Literature in Europe), the National Technical Information Service, the National Research Register (UK), and the Current Controlled Trials databases. Once we had gathered all relevant full text papers we reviewed each reference list for any omitted studies. Finally, we contacted corresponding authors of papers to identify any publications that had not been previously highlighted through the search strategies. A review protocol for this meta-analysis was not published or registered before we undertook this study.

**Eligibility criteria**—We included all full text randomised and non-randomised clinical trials comparing the outcomes of wound closure with skin staples or suture after orthopaedic surgery, comprising any orthopaedic operative procedure including trauma and elective procedures. We excluded papers assessing the effects of synthetic adhesives such as 2-octyl cyanoacrylate and editorials, comments, or letters based on methodological quality. We also excluded cadaveric or animal studies, citations that did not adhere to our study criteria, and studies that provided

insufficient information on population characteristics, surgical procedure, or outcomes.

**Study identification**—Two authors (TOS, DS) independently screened all titles and abstracts identified from the search strategy. The full texts for all potentially eligible studies that seemed to follow the selection criteria were ordered. These were then reviewed by each of the two independent reviewers again for eligibility against the predefined criteria.

**Data extraction**—The two reviewers (TOS, DS) then independently reviewed each eligible paper. Each reviewer extracted data on a predefined database. The two databases were then compared. Data collected from each paper included number of patients and operations, age, sex, operative procedure, closure method, grade of surgeon, antibiotic cover, and dressing applied as well as data on the incidence of wound infection, dehiscence, inflammation, discharge, necrosis, abscess formation, allergic reactions, length of stay in hospital, closure time, and patients’ satisfaction and pain.

**Critical appraisal**—Each reviewer (TOS, DS) critically appraised each study using the Physiotherapy Evidence Database (PEDro) critical appraisal tool. This is an 11 item scoring system, which is reliable and valid in the assessment of randomised controlled trials.<sup>12 13</sup> Any disagreements regarding study selection, data extraction, or appraisal score were resolved through discussion.

**Outcome measures**—Our primary outcome was the incidence of wound infection after skin staples compared with suture closure after orthopaedic surgery. The secondary outcomes under investigation included the incidence of wound dehiscence, inflammation, discharge, necrosis, abscess formation, allergic reactions, length of stay, closure time, and patients’ satisfaction and pain.

**Statistical analysis**—One author (TOS) conducted all statistical analyses using Review Manager 5.0 (Nordic Cochrane Centre, Cochrane Collaboration 2009, Copenhagen, Denmark). When we found no evidence of a substantial difference in study populations, interventions, or outcome measurements, we carried out a meta-analysis. We assessed statistical heterogeneity with  $\chi^2$  and  $I^2$ . In each analysis, if  $\chi^2$  heterogeneity was reported as  $P > 0.05$ , and the  $I^2$  statistic indicated that heterogeneity was low ( $< 20\%$ ),<sup>14</sup> we used a fixed effect model to calculate the total relative risk ratio or mean difference and 95% confidence interval. Otherwise we used a random effects model. After this, we used the mean pooled difference to assess for continuous data, while pooled relative risk ratios were assessed for all dichotomous data with the Mantel-Haenszel method.<sup>15</sup> A probability of  $P < 0.05$  was determined as significant, and 95% confidence intervals were also calculated. Subgroup analyses were prespecified before data collection to compare the results separately of skin staples and sutures in hip, knee, spinal, and upper extremity procedures. When insufficient data were presented in the full text publication, we attempted to contact all corresponding authors. Finally, we used a funnel plot to test for

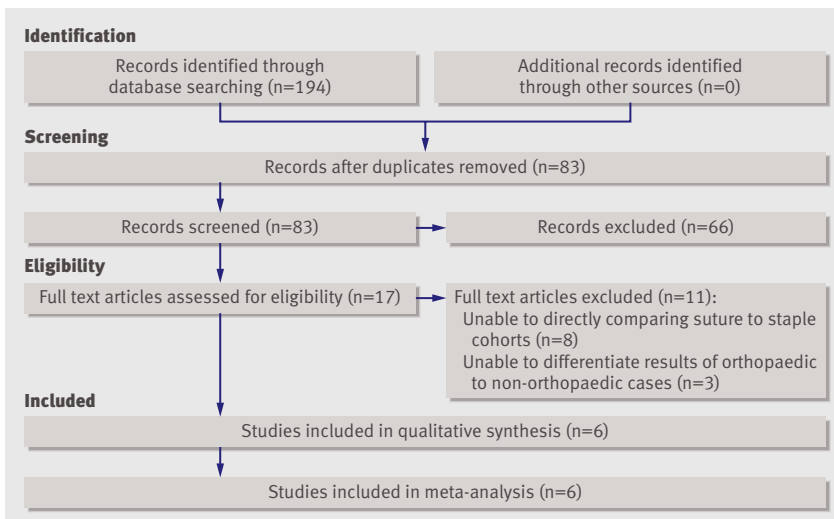
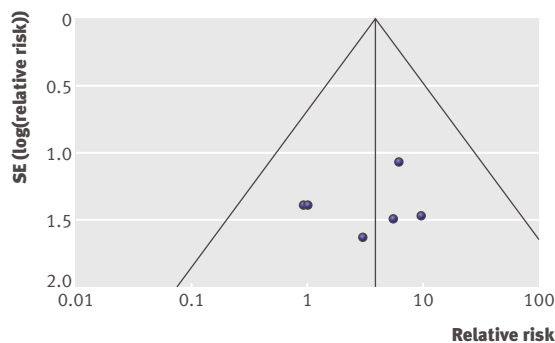


Fig 1 | Flow of identified studies



**Fig 2** | Publication bias funnel plot for incidence of wound infection after orthopaedic surgery

potential publication bias for the outcome measure that was most commonly presented in the papers reviewed.

## RESULTS

### Systematic review

The search retrieved 194 records of possible relevance. Of these, six adhered to the predefined selection criteria and were included in the review. Figure 1 shows the results of the search strategy. The assessment of publication bias with frequency of wound infection in all orthopaedic procedures indicated no substantial evidence of publication bias (fig 2).<sup>16</sup> Only one study had acceptable methodological quality.

### Population characteristics

In total, 683 patients were included in this review; 332 patients underwent suture closure and 351 staple closure. Four studies provided data on sex<sup>12,4,17</sup>; there were 60 men and 131 women in the suture group and 57 men and 117 women in the staple group. Table 1 shows that three studies assessed the outcomes after hip surgery,<sup>2,4,17</sup> two studies assessed a mixture of hip and knee arthroplasty patients,<sup>1,10</sup> and one study assessed outcomes after upper and lower limb trauma surgery.<sup>9</sup> In the three papers that provided relevant information, the mean age was 79.7 (SD 3.7) in the suture group and 81.6 (SD 5.0) in the staple group. Routine antibiotics were administered in four studies.<sup>12,10,17</sup> The time for suture or staple removal ranged from 10 days to 16 days. The mean follow-up period was 95 days (SD 136.9).

## Meta-analysis

### All orthopaedic procedures

Six outcomes could be assessed with meta-analysis. The risk of a wound infection was over three times greater with staples than with sutures ( $P=0.01$ ; fig 3). There was no significant difference in the relative risk of wound discharge, inflammation, necrosis, dehiscence, or allergic reaction ( $P>0.05$ ; table 2). Only the assessment of wound inflammation exhibited substantial statistical heterogeneity ( $I^2=85\%$ ).

In the study by Stockley and Elson<sup>10</sup> a higher proportion of patients reported considerable pain with removal of staples compared with the proportion who did so with removal of sutures. This was not assessed with inferential statistics.

Only Singh et al assessed the cost effectiveness of the two methods of wound closure.<sup>2</sup> 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. They reported that this would be a difference of about £1m (€1.1m, \$1.5m) a year, based on the incidence of about 750 000 fractures of the neck of the femur each year.

Khan et al compared length of stay in hospital and patients' satisfaction between wound closure methods in their patients undergoing hip and knee surgery.<sup>1</sup> They found no significant difference between methods in the two groups ( $P>0.05$ ). They did, however, report that wound closure was significantly faster with staples than with sutures ( $P<0.05$ ) and that there was no significant difference in cosmesis according to the Hollander wound evaluation score.<sup>18</sup> Finally, two patients developed wound abscesses, one after total knee replacement and one after total hip replacement.<sup>1</sup> In both cases closure was with sutures.

### Hip surgery

Five studies provided data on methods of wound closure after hip surgery.<sup>12,4,10,17</sup> Four outcomes were appropriate to assess with meta-analysis. The risk of a wound infection was over four times greater in those cases where the wounds were closed with staples than with sutures ( $P=0.02$ ; fig 4). There was no significant difference between the incidence of wound discharge, dehiscence, or allergic reaction between the two methods after hip surgery ( $P>0.05$ ; table 3).

**Table 1** | Details of included papers comparing methods of wound closure after orthopaedic surgery

	Operation	Closure material	Wounds		Mean age (years)		Sex		Time to removal (days)	Follow-up (days)
			Suture	Staple	Suture	Staple	Suture	Staple		
Clayer and Southwood <sup>17</sup>	THR, hip fracture surgery	Subcuticular polypropylene; skin staples	33	33	75.4	75.9	11/22	10/23	10-14	84
Khan et al <sup>1</sup>	THR, TKR	Absorbable suture; skin staples	64	63	NS	NS	3331	3033	10	84
Murphy et al <sup>9</sup>	ORIF ankle, tibia, patella, femur, forearm, olecranon, humerus	Nylon suture; clips	29	31	NS	NS	NS	NS	13	13
Shetty et al <sup>4</sup>	Hip fracture surgery	Subcuticular vicryl; metallic skin staples	47	54	81.7	83.5	740	1341	10	10
Singh et al <sup>2</sup>	Hip fracture surgery	Subcuticular vicryl; clips	30	41	82	85.4	624	734	10	14
Stockley and Elson <sup>10</sup>	THR, hip and knee ORIF, TKR	Nylon suture; skin staples	129	129	NS	NS	NS	NS	10-16	365

THR=total hip replacement, TKR=total knee replacement, NS=not stated, ORIF=open reduction internal fixation.

**Table 2** | Outcomes of suture compared with staple wound closure in orthopaedic surgery

	Incidence		Relative risk (95% CI)	Overall effect (P value)	Heterogeneity	
	Suture	Staple			I <sup>2</sup> (%)	χ <sup>2</sup> P value
Discharge <sup>1 2 9</sup>	8/124	17/134	1.54 (0.31 to 7.80)	0.60	59	0.09
Inflammation <sup>2 9</sup>	3/60	22/71	4.69 (0.08 to 269.80)	0.46	85	0.01
Infection <sup>1 2 4 9 10 17</sup>	3/333	17/350	3.83 (1.38 to 10.68)	0.01	0	0.76
Wound necrosis <sup>9 10</sup>	1/158	3/160	2.26 (0.34 to 14.88)	0.40	0	0.41
Dehiscence <sup>2 4 9 17</sup>	1/140	5/158	2.30 (0.54 to 9.84)	0.26	0	0.90
Allergic reaction <sup>1 10</sup>	1/193	1/192	1.01 (0.14 to 7.12)	0.99	0	0.99

Two studies assessed wound cosmesis. Clayer and Southwood<sup>17</sup> reported that the scars produced by suture closure were significantly thinner than with staples after hip surgery (P<0.05). Khan et al, however, reported no significant difference between wound closure method and the Hollander wound evaluation score after hip surgery (P>0.05).<sup>1</sup>

*Knee surgery*

Two studies were identified compared the outcomes of sutures with staples after knee surgery.<sup>1 10</sup> Only the incidence of wound infection could be assessed with a meta-analysis. This suggested that there was no significant difference between the groups after knee surgery (P=0.20; table 3). As in hip surgery, there was no significant difference in the Hollander wound evaluation score between suture compared with staple closure after knee surgery (P>0.05).

*Spinal surgery*

We did not find any studies that examined outcomes of wound closure with sutures compared with staples after spinal surgery.

*Upper limb*

Only one study was identified that examined the outcomes of wound closure with sutures compared with staples after surgery to the forearm, olecranon, and humerus.<sup>9</sup> The results were not presented independently from those for lower limb surgery. It was therefore not possible to determine whether there was a difference in outcome between these two methods of wound closure in orthopaedic procedures in upper limbs compared with lower limbs.

**Critical appraisal**

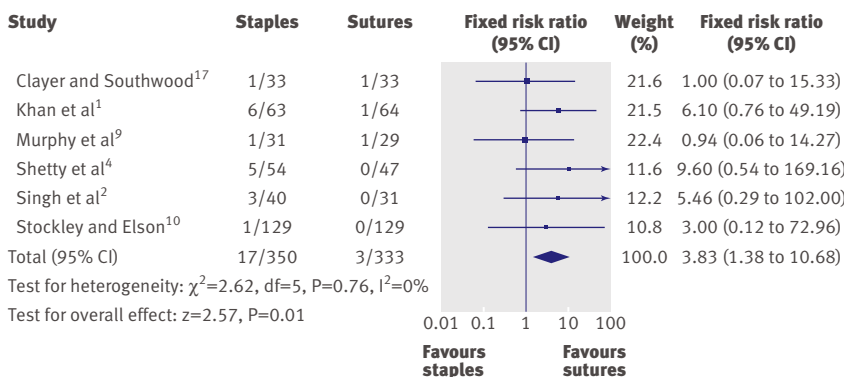
Critical appraisal of the six included studies showed considerable variation in methodological quality (table 4). Only half of the studies were randomised controlled trials. Khan et al<sup>1</sup> and Shetty et al<sup>4</sup> concealed allocation to limit allocation bias. Only half of the studies tested baseline comparability to ensure that the two groups were equal before wound closure.<sup>1</sup> Similarly, only one study blinded participants and assessors to the method of wound closure by covering the wound with a dressing, in an attempt to limit assessor bias. While all studies except Stockley and Elson<sup>10</sup> compared the results of their two groups using inferential statistics, only Khan et al<sup>1</sup> and Murphy et al<sup>9</sup> followed intention to treat principles in data analysis. Furthermore, Khan et al<sup>1</sup> presented their results using confidence intervals.

**DISCUSSION**

After orthopaedic surgery, there is a greater risk of wound infection in patients whose wounds are closed with metallic staples than with sutures. Our meta-analysis showed no significant difference between the two closure methods with respect to wound discharge, inflammation, necrosis, dehiscence, or allergic reaction. We consider, however, that only one study had acceptable methodological quality.<sup>1</sup> The remaining evidence base presented considerable methodological limitations, including not justifying sample sizes based on a power calculation, poorly blinding patients and assessors to the method of wound closure, not adequately following up patients over a reasonable period of time, and poorly detailing the allocation method to the two groups. While it might be difficult to blind assessors to the method of wound closure, particularly within the initial postoperative month, blinding of patients is logistically possible. Accordingly, such limitations should be considered in the design of future studies to improve the evidence base.

**Comparison with other studies**

Factors that have been cited as important in the choice of wound closure after orthopaedic surgery have included the ease and speed of closure, the level of patients' discomfort, the complication rate, the final cosmetic result, and the cost.<sup>2</sup> Early studies had suggested that the incidence of wound infection might be reduced with staples because of the mechanism of fixation. Johnson et al<sup>19</sup> and Stillman et al<sup>20</sup> suggested that



**Fig 3** | Incidence of infection for wounds closed with sutures or staples

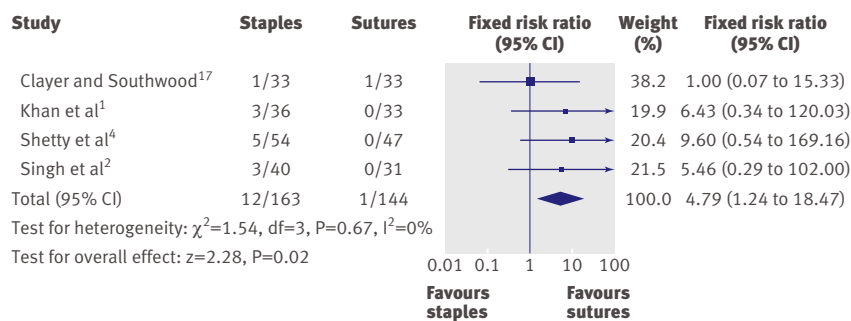


Fig 4 | Incidence of infection for hip wounds closed with sutures or staples

skin stapling might cause less damage to the wound's defences than non-absorbable sutures. This was based on the principle that the presence of a foreign material might compromise the immune response. Furthermore, Pickford et al suggested that as staples do not penetrate the incision but cross the incision site, this might prevent the introduction of foreign material.<sup>21</sup> Our findings, however, suggested the contrary—namely, that wounds closed with staples rather than sutures have four times the risk of infection. Whether this is a consequence of the clip being metallic rather than vicryl or nylon material or whether the tension developed through a mattress suture closure is superior to that of staples in reducing the incidence of opening the wound during mobilisation remains unclear. Our conclusion was reached, however, after application of the statistical method for the whole evidence base and was significant for hip surgery but not knee surgery. The rationale for this has been postulated by Khan et al,<sup>1</sup> who pointed out that knee wounds are considerably longer than hip wounds and are subjected to more mobility as they are covered by less tissue. As only 88 patients have been assessed in relation to knee wound closure with staples compared with sutures, this observation remains underpowered at present.

It remains unclear as to whether there was a difference in cosmetic result between wounds closed with sutures or staples after orthopaedic surgery.<sup>1,17</sup> As the present included studies did not analyse the results based on different comorbidities, age, or skin type, we do not know whether patients with difference skin types might present with differing outcomes—for example, Afro-Caribbean patients are more susceptible to hypertrophic and keloid scarring.<sup>22</sup>

Previous studies have examined the clinical outcomes of skin closure with continuous or subcuticular interrupted suture techniques for repair of episiotomy or second degree perineal tears<sup>23-25</sup> and vascular surgery.<sup>26,27</sup> Most orthopaedic studies used interrupted subcuticular suture techniques for wound closure, while only two studies adopted a continuous suture technique.<sup>9,10</sup> There were no substantial differences in the trends in results between these two studies and the other studies included in this review. As this has yet to be empirically studied, it is therefore unclear whether the method of suture closure is a confounding variable with respect to the rate of complications, the patients' reported satisfaction for cosmetic results, and the discomfort reported through the removal of suture material.

Graham et al<sup>28</sup> proposed that deposition of wound collagen is directly related to wound oxygenation and perfusion.<sup>29,30</sup> They reported more favourable blood perfusion characteristics in wounds closed with staples rather than sutures, in addition to a significantly higher blood contact in the wound at seven days compared with the suture group ( $P=0.02$ ).<sup>28</sup> We found that the incidence of wound infection was greater with staples than with sutures. Therefore, our findings do not confirm those of Graham et al,<sup>28</sup> as oxygen perfusion might be associated with wound infection and necrosis. The influence of oxygen perfusion in hip wounds and knee wounds, which was assessed in the study of Graham et al,<sup>28</sup> remains unclear.

Murphy et al suggested that poor results with staples were attributable to poor technique in staple placement.<sup>9</sup> The accuracy of suture or staple closure and choice of closure method can have an effect on the accuracy of coaptation of the dermal margins. Poor technique can lead to suboptimal healing.<sup>10</sup> This might cause oozing wound edges and delay in healing and increase the potential for infection.<sup>8,9</sup> Superficial infection in hip and knee arthroplasty is a worrying clinical sign because of the risk of the infection spreading through the dermal layers to the implant. With the increased pressure on surgical time, and the advances in non-medical staff taking extended roles in wound closure, such considerations might be important when considering outcomes within each institution.

Metal staples have been regarded as a more expensive option for wound closure,<sup>9,10</sup> though costs could be reduced by reduced theatre time and ease of clip removal compared with suturing wounds. This might

Table 3 | Outcomes of suture compared with staple wound closure in hip and knee surgery

	Incidence		Relative risk (95% CI)	Overall effect (P value)	Heterogeneity	
	Suture	Staple			I <sup>2</sup> (%)	$\chi^2$ P value
<b>Hip surgery</b>						
Discharge <sup>1,2</sup>	2/64	13/76	3.85 (0.27 to 54.00)	0.32	62	0.10
Infection <sup>1,2,4,17</sup>	1/144	12/163	4.79 (1.24 to 18.47)	0.02	0	0.67
Dehiscence <sup>2,4,17</sup>	0/111	4/127	3.19 (0.53 to 19.18)	0.21	0	0.98
Allergic reaction <sup>1,10</sup>	1/132	1/135	0.96 (0.14 to 6.58)	0.97	0	0.32
<b>Knee surgery</b>						
Infection <sup>1,10</sup>	1/61	4/57	3.29 (0.54 to 20.04)	0.20	0	0.94

Table 4 | PEDro critical appraisal results showing whether each study satisfied criteria

	Clayer and Southwood <sup>17</sup>	Khan et al <sup>1</sup>	Murphy et al <sup>9</sup>	Shetty et al <sup>4</sup>	Singh et al <sup>2</sup>	Stockley et al <sup>10</sup>
Eligibility criteria	Yes	Yes	No	No	No	No
Random allocation	No	Yes	Yes	Yes	No	No
Concealed allocation	No	Yes	No	Yes	No	No
Baseline comparability	Yes	Yes	No	No	Yes	No
Blinded patient	No	Yes	No	No	No	No
Blinded clinician	No	No	No	No	No	No
Blinded assessor	No	Yes	No	No	No	No
Adequate follow-up	Yes	No	No	No	No	Yes
Intention to treat analysis	No	Yes	Yes	No	No	No
Between group analysis	Yes	Yes	Yes	Yes	Yes	No
Point estimates and variability	Yes	Yes	Yes	No	No	No
Total score	5	9	4	3	2	1

prove to be false economy, however, as the consequences of a deep infection for the patient are substantial through the increased costs associated with medical care and admission to hospital.<sup>31</sup> Furthermore, as the number of dressing changes was greater in those who underwent skin stapling, and as a specific staple remover is required, the overall cost of the staples and applicator is mitigated by savings in dressing costs. Although Singh et al estimated the cost effectiveness of these two closure methods,<sup>2</sup> no formal cost-benefit analysis has been undertaken.

One study assessed patients' satisfaction<sup>1</sup> and reported no significant difference between the groups.<sup>1</sup> Stockley and Elson<sup>10</sup> and Singh et al<sup>2</sup> reported that staples were invariably more painful to remove than sutures. The relative discomfort of staple removal compared with suture removal has been previously cited in the non-orthopaedic literature.<sup>32-34</sup> Secondly, some authors have suggested that there might be greater satisfaction for surgeons in using staples than sutures. The time saving benefits of staples might have a psychological effect on surgeons and theatre staff, particular after a long operation.<sup>9,10,35</sup> Given the difference in the incidence of superficial wound infection, and the limited empirical evidence for patients' or surgeons' preference for staple closure, there is insufficient evidence to justify the use of staples over sutures.

Our findings can be directly generalised only to orthopaedic hip and knee arthroplasty surgery. Different methods of skin closure, however, have been assessed in other surgical procedures, such as scalp lacerations. While stapling has been shown to be faster and less expensive than suturing in the repair of uncomplicated scalp lacerations in children and adults, no differences in complication rates, including infection, have been shown.<sup>36-38</sup> Similarly, there was no significant difference in complications after abdominal wound closure.<sup>39</sup> In this specific population, however, stapling resulted in poorer cosmetic scores than suturing in transverse abdominal wounds.<sup>39</sup> Ranaboldo and Rowe-Jones reported that wound pain and requirement for analgesia was significantly lower in patients whose laparotomy wounds were closed with sutures

compared with staples.<sup>40</sup> Finally, a systematic review of methods of skin closure in caesarean section reported that use of absorbable subcuticular sutures resulted in less postoperative pain and yielded a better cosmetic result than staples.<sup>41</sup> While there seems to be consensus that staple closure is faster than suture closure, there remains some variation between studies for cosmetic results and pain outcomes. There seemed to be no significant difference in complication rates, including wound infection, between caesarean wounds closed with sutures compared with staples, contrary to our findings. By re-evaluating this issue with well designed randomised controlled trials it will be possible to compare the findings of orthopaedic to other surgical procedures.

#### Strengths and limitations

We found no significant difference in the presentation of inflammation for wounds closed with sutures rather than staples, which was unexpected given the differences exhibited between methods for infection. This outcome, however, was assessed in only two studies with small cohorts so the lack of a statistical difference might have been because of type II statistical error.<sup>42</sup> We also noted considerable heterogeneity, possibly as a consequence of the small number of patients reviewed, so it might be inappropriate to use these results based on the current pooled analysis. Further study of the effect of inflammation as an outcome with large sufficiently powerful samples is therefore indicated to assess whether this outcome measure differs between orthopaedic wounds closed with sutures compared with staples.

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 wash-out, prosthesis revision surgery, and, potentially, amputation.

**WHAT IS ALREADY KNOWN ON THIS TOPIC**

Orthopaedic surgeons use both metallic staples and nylon sutures to close wounds

Controversy exists as to the best method of wound closure after orthopaedic procedures such as lower limb joint arthroplasty, reconstructive surgery, and trauma fixation

**WHAT THIS STUDY ADDS**

In orthopaedic surgery the risk of infection after staple closure was three times the risk with suture closure; after hip surgery the risk was four times greater

To minimise wound infection, orthopaedic surgeons should close wounds with sutures rather than staples

Only one of the studies included in the meta-analysis was of acceptable methodological quality

The evidence base poorly presented important demographic details for their cohorts. For example, only three studies provided data on patients' age. Accordingly, we could not assess whether this was an important variable between the two groups. Similarly, the studies poorly presented details regarding patients' medical history, use of steroids, weight, and body mass index, which might also have been confounding variables. Propensity scoring methods would compensate for potential differences in important characteristics.<sup>43</sup> As only Khan et al<sup>1</sup> and Shetty et al<sup>4</sup> concealed patient allocation, allocation bias might have affected findings because the patient's clinical presentation might have influenced the surgeon's choice of methods before randomisation. Concealed randomisation should therefore be considered in the design of future research to prevent such bias.

Only the study of Khan et al can be judged as methodologically well designed and appropriately reported.<sup>1</sup> The remaining papers reviewed had considerable limitations. Given that Khan et al's cohort constituted 19% of the total meta-analysis cohort,<sup>1</sup> the weaker studies might have considerably affected our results. Accordingly, we recommend that further well designed randomised controlled trials are conducted to further examine the results of this meta-analysis. After this, orthopaedic surgeons will then be able to justify their use of closure method by using a more rigorous evidence base than is currently available.

Finally, nearly all identified papers compared the outcome of method of wound closure in hip surgery. We did not find any studies assessing the effect of different methods in spinal surgery, only one study was identified on the effects of knee surgery, and only Murphy et al's study included patients who had undergone upper limb surgery.<sup>9</sup> The limited evidence, particularly in upper limb surgery, might reflect a predominance of suture closure after elbow, wrist, and hand surgery. The clinical justification for this might be on ease of sutured closure compared with staples in hand surgery or on an improved cosmetic result with sutures.

**Conclusions and policy implications**

Use of metal clips to close orthopaedic wounds, most notably in hip surgery, is associated with a significantly

greater risk of wound infection than traditional suturing. Given the methodological limitations identified, definitive randomised trials are needed to re-appraise this research question. With the current evidence, however, patients and doctors should think more carefully about the use of staples for wound closure after hip and knee surgery.

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