No differences in healing among different closure methods of arthroscopic portals: a systematic review

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ABSTRACT
Background During arthroscopy the small skin incisions made over the joints are called arthroscopic portals. There are different methods described for arthroscopic portal closure. Very few randomised controlled trials and no systematic reviews have compared the methods of arthroscopic portal closure, and there are no clear guidelines recommending any one closure method. There is therefore a need for a systematic review that provides high-quality evidence to help surgeons choose the appropriate arthroscopic portal closure technique.

Objective To undertake a systematic review to ascertain the outcome with three different closure methods for arthroscopic portals: (1) suturing; (2) application of sterile adhesive tapes; and (3) leaving wounds open covered with a dressing.

Methods Randomised controlled trials comparing the closure methods of arthroscopic portals were selected using strict search criteria from electronic databases (MEDLINE, EMBASE, CINAHL, BNI and Cochrane Library) and trial registers. Two independent authors conducted the study selection, data extraction and quality assessment of each study. Quality appraisal was done using the Cochrane Collaboration risk of bias tool. Three studies were eligible for inclusion and a narrative synthesis of the findings is provided.

Results One study did not show a statistically significant difference between suturing and leaving the wound open with a dressing. However, two studies found that leaving wounds open covered with a dressing had a significantly better outcome. In one of these studies, sterile adhesive tapes were used and the outcomes were better than with suturing but not so good as leaving the wounds open covered with a dressing.

Conclusion Suturing of arthroscopic portal wounds confers no benefit over leaving them open covered with a simple dressing or applying sterile adhesive tapes, and these are safe alternative techniques.

What is already known
There are no systematic reviews or any clinical guidelines that recommend any one method of arthroscopic portal closure.

What are the new findings
Suturing of arthroscopic portals confers no benefit over managing them by leaving them open covered with a simple dressing or applying sterile adhesive tapes, and these are safe alternative techniques.

INTRODUCTION
Arthroscopic surgery, commonly known as ‘keyhole surgery’, is a minimally invasive procedure performed inside a joint by visualising through a small camera called an arthroscope.3 Common joints on which arthroscopic surgery is performed are the knee, shoulder, hip, ankle and wrist joints.2 Recent advances in technology have enabled the use of small incisions called ‘arthroscopy portals’; the number of such portals will depend on the type of procedure and surgeon preference.1 After the procedure is finished, these arthroscopy portals are closed and covered with a dressing. They will generally be reviewed 10–14 days postoperatively and followed up at 12 weeks.3–5

Arthroscopy is generally a day surgery procedure and any complications afterwards such as joint stiffness and swelling are usually minor and temporary. The major or long-term complications reported include infections, haemarthrosis, adhesions, effusions, cardiovascular, neurological, reflex sympathetic dystrophy, instrument breakage and injury to the articular cartilage. More serious complications are much rarer, occurring in less than 1 in 100 cases.1

Minor complications reported are related to wound healing in approximately 10% of cases.6–10 They include local pain, haematoma, bruising, delayed healing, nodular enlargement, discharge, infection, erythema, scar formation, cosmetic problems and synovial fistulae.6–9 11 12

Goals for the most optimal skin closure technique are adequate tissue approximation, minimal risk of infection, an acceptable cosmetic result, quick, cost-effective method and minimal postoperative pain.13 14 The ideal wound closure technique should be cost-effective, time-effective and user-friendly with an optimal cosmetic outcome. The optimal method of skin closure in orthopaedic surgery remains unclear.15 In this systematic review, three methods of arthroscopic portal closure were

studied: (1) suturing; (2) application of sterile adhesive tapes; and (3) leaving wounds open covered with a dressing.

**Suturing technique**
The portal wound is sutured with either non-absorbable skin stitches or absorbable subcuticular stitches. The advantage is that the skin edges are well approximated. Precise approximation of wound edges during the suturing process can result in negligible scarring and minimal evidence of stitching, thus enhancing patient satisfaction.

The disadvantage is that there is a need to review at 2 weeks for removal of skin stitches or to check that no absorbable stitches are left behind. The removal of non-absorbable stitches can cause apprehension to the patient and the suture material itself can cause potential irritation or injury to the skin. Sometimes stitching of a wound can be too tight causing sealing of the joint, thereby preventing required oozing that drains the fluid from the soft tissues introduced during arthroscopy. Sutures have shown bacterial colonisation on surfaces until they are removed.

**Applying sterile adhesive tapes (Steri-strips)**
The wound edges are approximated to apply the sterile adhesive tapes. Advantages of this technique are the need for minimal intervention as small incisions are not expected to see any stress, no risk of needlestick injury and less pain in the immediate post-operative period. Other advantages include quick application, easier wound care, cost effectiveness and no need for suture removal. A decrease in wound erythema has been highlighted by studies reporting an improved wound appearance. One study reported that the strength and toughness of wounds were comparable when closed with either surgical tape or suture material after about 20 days of healing.

**Leaving wounds open covered with a simple sterile dressing**
Many studies have shown that sutureless treatment of portal incisions appears effective with lower rates of superficial infection, haematoma and scarring.

The National Institute for Health and Care Excellence (NICE) has not made any recommendations on surgical closure methods because of the inconsistencies in the evidence. It recommends further research on the use of different suture materials and skin adhesives and their effect on the rate of surgical site infection. There are few randomised controlled trials or other clinical studies comparing the methods of arthroscopic portal closure, and no systematic reviews have evaluated arthroscopic portal closure methods. The current clinical practice has been largely based on the preference of individual surgeons. There is therefore a need for a systematic review that provides high-quality evidence to help surgeons choose the most appropriate arthroscopic portal closure method.

**Aim and objective**
To undertake a systematic review to ascertain the outcome comparing three methods for the closure of arthroscopic portals: (1) suturing; (2) sterile adhesive tapes; and (3) leaving wounds open covered with a simple sterile dressing. The comparison was done with respect to the primary outcome measure—namely, wound healing—assessed by cosmetic appearance and patient satisfaction; the secondary outcome measures were pain and any complication such as infection, redness or swelling.

**METHODS**
The systematic review protocol was completed and formally registered at the Faculty of Health and Social Care at Edge Hill University, Ormskirk, UK at the project proposal stage prior to starting this literature review.

The information used in this systematic review was obtained from publically available sources and did not contain confidential patient information. As a result, ethical approval was not needed. In this systematic review the objective was the same as in the individual included studies, so informed consents given in the included studies were still valid.

**Inclusion and exclusion criteria**
Studies included were those comparing closure of the arthroscopy portal by one of the three methods (sutting, applying sterile adhesive tape (Steri-strips) or leaving wounds open covered with a simple sterile dressing). The participants were of all age groups who had undergone arthroscopic surgery. Only studies involving closure of the skin layer of the arthroscopic portals were included. Studies describing internal closure techniques were excluded.

Exclusion criteria included studies involving patients undergoing open arthroscopically-assisted procedures such as anterior cruciate ligament reconstruction, those involving large portals where a cannula was used and complex instrumentation was performed, patients with pre-existing infection, inflammatory conditions or metalwork around the joint and those who had had previous same joint surgery.

Only randomised controlled trials (level 1b evidence) were included.

**Literature search for identification of studies**
A thorough comprehensive literature search was carried out to identify studies published up to 30 March 2016. No time limit for publications was set. The search keywords used were: ‘arthroscopy’, ‘portal’, ‘wound’, ‘closure’, ‘management’.

An electronic search was undertaken of NICE Evidence journals and databases such as MEDLINE, EMBASE, CINAHIL, BNI and the Cochrane Library database. Hand searching was performed of key orthopaedic journals and wide internet searching of the OpenGrey website, Google Scholar, NHS Evidence Search, Journal libraries and websites for orthopaedics and professional societies. Online trial registers were searched to identify completed and ongoing clinical trials. Citation searching was undertaken. Experts in the field of arthroscopy and sports surgery were contacted to enquire about any ongoing studies. The results of the literature searches were all combined and duplicates were deleted.

**Data collection and analysis**
Two independent reviewers were involved in reviewing the search results. The titles and abstracts and then the full-text articles were screened against the inclusion and exclusion criteria. In case of any differences of opinion, a third independent reviewer was consulted.

The Cochrane Collaboration’s recommended tool was used for assessing the risk of bias in the included studies. Two review authors independently assessed the studies for risk of bias. A third reviewer was contacted in case of any disagreement. Summary assessment of the risk of bias for each important domain within each study was performed. Any assessment of the overall risk of bias involves consideration of the relative importance of different domains.
Data synthesis

Meta-analysis could not be done as the number of included studies was small and they were not sufficiently homogeneous in terms of participants, intervention comparison groups, methodological factors such as risk of bias and in the way the outcomes were defined and measured, which may be expected to lead to differences in the observed intervention effects.2 The heterogeneity evident in the included studies with different degrees of bias is shown in tables 1 and 2. Data analysis was performed in a narrative way by giving a structured summary and discussion of the study characteristics and results.

PRISMA guidelines were followed throughout all the stages of this review.43

RESULTS

Three studies were selected for inclusion in the systematic review (see PRISMA flowchart in figure 1).3–5 43

Overview of the included studies

Two studies compared two methods of arthroscopic portal closure: suturing and leaving wounds open covered with simple sterile dressing3 5 and one study compared three methods: suturing, applying sterile adhesive tape (Steri-strips) and leaving wounds open covered with a simple sterile dressing.4 The characteristics of each study have been summarised in table 1.3–5

Description of excluded studies

After full-text assessment of 12 studies, it was found that eight studies did not satisfying the inclusion criteria10 16 28 34 35 44–46 and there was one instance of dual/multiple publications of the same study.47

Patil et al44 in their study stated that patients were alternatively allocated into groups which would be considered as a quasi-random method of allocation and not a true randomisation.34 41

Result of quality assessment

The included studies were assessed using the Cochrane Collaboration risk bias tool,41 as shown in table 2.3–5

The three eligible trials address a clearly focused issue.3–5 All the included studies were single-centre studies, which can affect the generalisability of the study results; multicentre trials increase the generalisability of the study.

As per the Cochrane Collaboration risk bias tool,41 any assessment of the overall risk of bias involves consideration of the relative importance of different domains. Reviewers came to a consensus that the domains most important in this systematic review were random sequence generation, allocation concealment and selective reporting.

Summary assessment of the risk of bias for each important outcome (across domains) in each study suggests that the study by Loveridge et al4 found a low risk of bias across the important domains3 and the studies by Maffulli et al5 and Sikand et al4 had an unclear risk of bias.3 4

Results of included studies

The reviewers decided to conduct a narrative synthesis to explore any patterns identified across the results and possible factors explaining the variations in the study findings.40 41 However, since statistical heterogeneity could not be assessed, this type of narrative analysis will focus instead on clinical or methodological factors that might explain variability among studies.50

Primary outcome: wound healing

Wound healing was the primary outcome measure and it was assessed based on cosmetic appearance and patient satisfaction.

The cosmetic outcome of the wounds managed with different closure methods is summarised in table 3.3–5 The study by Loveridge et al4 did not report any statistically significant difference for cosmetic outcome between the groups managed by suturing and leaving open with just a dressing. The study by Maffulli et al5 and Sikand et al4 found that the group in which portals were managed by leaving open covered with a dressing had a significantly better cosmetic outcome. The study by Sikand et al4 also included a third group in which portals were managed with sterile adhesive tapes, and its outcomes were better than suturing but not as good as leaving wounds open covered with a dressing.4

The assessment of patient satisfaction after wound management with different closure methods is summarised in table 4.4 5 The study by Loveridge et al4 did not report any statistically significant difference between groups managed by suturing and leaving open with just a dressing.3 However, the study by Sikand et al4 included a third group in which portals were managed with sterile adhesive tapes and its outcomes were better than suturing but less good than leaving wounds open covered with a dressing.4

Secondary outcomes

Pain at arthroscopy portal site

As shown in table 5,4 the study by Loveridge et al4 found no statistically significant difference in pain at the arthroscopic portal site in the three groups (suturing, sterile adhesive tapes and leaving portals open with just dressing).4 The studies by Maffulli et al5 and Loveridge et al4 did not consider pain as an outcome measure.3 5

This shows that there was no difference in pain between the three methods of arthroscopic portal closure.

Complications

Wound-related complications reported in all the included studies were redness, swelling, haematoma, blood seepage, crosshatching at the wound and superficial abscess/infection.3–5 They are summarised in table 6.3–5

The study by Loveridge et al4 did not report any statistically significant difference in complications between the groups in which portals were managed with suturing and leaving open with just a dressing.3 4 However, the studies by Maffulli et al5 and Sikand et al4 conclude that complications were significantly less in the group in which portals were managed with leaving wounds open covered with a dressing. There were no major or long-term complications reported in any of the three included studies. None of the included studies demonstrated a negative or detrimental effect of leaving portals open with a dressing.

Cost analysis

All three included studies3–5 concluded that managing arthroscopic portals by leaving them open covered just with a dressing would be cost-effective compared with suturing. However, they have not done a detailed cost analysis.

DISCUSSION

In this systematic review a total of 320 patients who underwent arthroscopy were included. In 140 patients the arthroscopic portals were managed with suturing, in 52 patients the portals...
### Table 1 Description of studies selected for quality appraisal (a – c) 3–5

<table>
<thead>
<tr>
<th>Study</th>
<th>Methods</th>
<th>Population</th>
<th>Outcome</th>
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<tbody>
<tr>
<td><strong>a)</strong> Study: Maffulli, Pintore and Petricciolo (1991), UK 3</td>
<td>Prospective randomised controlled trial</td>
<td>Inclusion- Patients undergoing arthroscopy of their knee joint. Exclusion- Not defined.</td>
<td>Over a 10 month period, 100 Caucasian patients underwent arthroscopy. Arthroscopies performed through 5 mm stab wounds. In each knee, all wounds were either sutured (one plain silk suture stitch) or not sutured.</td>
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<td></td>
<td>Blinding- Not mentioned</td>
<td>Suturing</td>
<td>Follow-up- No patients were lost.</td>
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<td></td>
<td>Conflicts of interest- Not mentioned</td>
<td>Not suturing &amp; simple bandage</td>
<td>Reviewed at 2 and 12 weeks.</td>
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<td></td>
<td>Ethical clearance- Not mentioned</td>
<td></td>
<td>Outcome measures</td>
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<tr>
<td></td>
<td>Informed consent- Not mentioned</td>
<td>Total</td>
<td><strong>p</strong>-value</td>
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<tr>
<td></td>
<td>Randomisation- No details of randomisation process.</td>
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<td>Author’s inference</td>
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<td></td>
<td>Statistical methods- Results were analysed using chi-square test. Significance was accepted at the p= 0.05 level, or less.</td>
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<tr>
<td></td>
<td></td>
<td>Number of patients</td>
<td>Cosmetic appearance after wound healing (3-point scale)</td>
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<td></td>
<td></td>
<td>47</td>
<td>2.1 +/-0.81</td>
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<td>53</td>
<td>1.3 +/- 0.4</td>
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<td>100</td>
<td>0.031</td>
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<td></td>
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<td>Total number of wounds</td>
<td>Wound related complications (Number of patients with complications)</td>
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<tr>
<td></td>
<td></td>
<td>152</td>
<td>5</td>
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<td></td>
<td></td>
<td>178</td>
<td>3</td>
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<td></td>
<td></td>
<td>330</td>
<td>0.042</td>
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<td></td>
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<td>Average age in years (+/- SD) (in years)</td>
<td>Haematomas</td>
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<td>34.7 (6.5)</td>
<td>5</td>
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<td></td>
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<td>37.9 (9.3)</td>
<td>3</td>
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<td></td>
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<td>Not mentioned</td>
<td>Not mentioned</td>
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<td></td>
<td></td>
<td>Male: Female</td>
<td>Superficial abscess</td>
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<tr>
<td></td>
<td></td>
<td>36.11</td>
<td>4</td>
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<td></td>
<td></td>
<td>42.11</td>
<td>1</td>
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<td></td>
<td>Not mentioned</td>
<td>Not mentioned</td>
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<td>Average duration of arthroscopic procedure (in minutes) (+/- SD)</td>
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<table>
<thead>
<tr>
<th>Study</th>
<th>Methods</th>
<th>Population</th>
<th>Outcome</th>
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<tbody>
<tr>
<td><strong>b)</strong> Study: Sikand, Murtaza and Desai (2006), UK 4</td>
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Continued
Methods

Prospective randomised controlled trial.
Blinded independent observer.
Conflicts of interest- No benefits or funds were received.
Ethical clearance- Not mentioned.
Informed consent obtained.
Randomisation- Patients prospectively entered into our study and randomised into three groups following informed consent:
Statistical methods- This was a pilot study. The study had a power of 90% and was designed to detect 10% difference in the outcome measures with 95% confidence and p < 0.05. Chi-squared tests and ANOVA analysis were used.

Population

Inclusion- Patients undergoing arthroscopy of the knee joint either for diagnostic or therapeutic procedures such as debridement, removal of loose bodies and washout.
Exclusion- Not defined.

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Suturing</th>
<th>Sterile adhesive tape</th>
<th>Covered with simple dressing</th>
<th>Total</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>63</td>
<td>52</td>
<td>45</td>
<td>160</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Average age in years</td>
<td></td>
<td></td>
<td></td>
<td>40 years (Range: 20 to 60)</td>
<td></td>
</tr>
<tr>
<td>Male: Female</td>
<td>61 (38%)</td>
<td>99 (62%)</td>
<td>61 (38%) Females</td>
<td></td>
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<tr>
<td>Mean operation time</td>
<td></td>
<td></td>
<td></td>
<td>32 minutes</td>
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</table>

Interventions

Surgeons of different grades carried out the procedure. All procedures were carried out through 5-mm stab incisions. The wound was closed either using a single nylon (3-0) suture or by using a sterile adhesive tape (steri-strips) or by covering the wound with simple sterile dressing.

Outcome

Follow-up- No patients were lost.
The wounds were checked by a nurse practitioner at 2 weeks and sterile adhesive tapes/sutures were removed. Any problems were reported to the medical staff. Followed up till the wounds heal.
At 4 weeks record of the healing was made by an independent observer who was blinded to the method of closure.

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Suturing</th>
<th>Sterile adhesive tape</th>
<th>Covered with simple dressing</th>
<th>p-value</th>
<th>Author’s comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outcome Wound healing assessed with patient satisfaction for cosmetic appearance and overall healing of the wound (Number of unhappy patients).</td>
<td>5 (8%)</td>
<td>0</td>
<td>0</td>
<td>0.37</td>
<td>Results were best in simple dressing group followed by steri-strip group and then suture group.</td>
</tr>
<tr>
<td>Secondary outcome Severity of pain (VAS score)</td>
<td>17</td>
<td>9</td>
<td>8</td>
<td>0.02</td>
<td>Statistically significant difference.</td>
</tr>
<tr>
<td>Swelling (number of patients with swelling)</td>
<td>18 (29%)</td>
<td>5 (11%)</td>
<td>6 (12%)</td>
<td>0.04</td>
<td>Statistically significant difference.</td>
</tr>
<tr>
<td>Redness (number of patients with redness)</td>
<td>23 (37%)</td>
<td>12 (23%)</td>
<td>4 (9%)</td>
<td>0.004</td>
<td>Statistically significant difference. The Suturing group had significantly more redness.</td>
</tr>
</tbody>
</table>

Major Complications- No major or long-term complication in all three groups although there was superficial infection in 2 patients in the suture group, which cleared with oral antibiotics.

Conclusion

Suturing the portals had no additional advantage. Little to choose between the other two methods and treating wounds with either simple dressing or steri-strips was easy, economical, causes less discomfort and resulted in fewer problems as compared to suture removal.

Limitations declared by authors

Sometimes difficult for the patient to qualify the exact nature and place of origin of pain as some patients did have underlying osteoarthritis and chronic knee pain. This was a potential confounding factor, and careful evaluation was done while documenting this.

c) Study- Loveridge et al. (2010), UK
**Systematic review**

**Methods**  
Prospective randomised controlled trial  
Blinded Independent observer  
Conflicts of interest- None declared  
Ethical clearance obtained  
Informed consent obtained  
Randomisation- Randomised by blinded envelope on the day of surgery to one of the two closure methods.

Statistical methods- The study was a pilot study and designed as a trial of equivalence. The power of the study was designed to detect a 10% difference in the outcome measures with 95% confidence and p < 0.05. The Mann–Whitney test was used to analyse nonparametric data.

**Population**  
Inclusion- All patients of the senior author attending hospital and listed for diagnostic shoulder arthroscopy, arthroscopic subacromial decompression and arthroscopic acromioclavicular joint excision.  
Exclusion- Patients who were unable to give informed consent. Patients for arthroscopic cuff repair or stabilisation as a result larger portals required.

**Patient characteristics**  
<table>
<thead>
<tr>
<th>Suturing Group (SG)</th>
<th>Covered only with sterile dressing/ Non-Suturing Group (NSG)</th>
<th>Total</th>
<th>P value</th>
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<tr>
<td>Number</td>
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<td>30</td>
<td>30</td>
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<td>60</td>
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**Intervention**  
The arthroscopic arthrotomy incisions were less than 10mm in length. One group had portals sutured with 3/0 nylon then covered with a sterile dressing; the other group had wounds covered by a sterile dressing only.

**Outcome**  
Follow-up- No patients were lost.  
Review at 10 to 12 days postoperatively at the general practitioner’s surgery for a wound check and removal of the suture as required.  
At 3 weeks and 3 months after surgery, review at clinic by a designated, blinded, observer for cosmetic appearance. Questionnaires given for satisfaction with wound appearance and any complications.

**Outcome measures**  
<table>
<thead>
<tr>
<th>Primary outcome</th>
<th>Sutured group &amp; Non-sutured group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmetic appearance after wound healing (VAS score)</td>
<td>26 patients in the SG and 27 patients in the NSG scored between 9 and 10, comprising an excellent cosmetic result. One patient in the SG scored between 6 and 7, whereas one patient in each group scored between 7 and 8 and two patients in each group scored between 8 and 9.</td>
<td>0.66 No statistically significant difference</td>
</tr>
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</table>

**Secondary outcomes**  
| Patient satisfaction with wound healing (VAS score) | Two slightly outlying results in both the sutured group (SG) and non-sutured group (NSG). | 0.46 No statistically significant difference |
| Pain (VAS score) | Large variation in these scores, although patients in the NSG had larger numbers scoring less pain than the SG. Authors considered that the pain scores were multi-factorial and more dependent on the nature of the arthroscopic procedure, as well as the patient’s perception of pain, rather than on the closure technique. | This was therefore not considered to contribute to the study. |
| Any complications such as infection, the number of dressing changes needed postoperatively | No signs of wound infection during any of the follow-up appointments. In both the SG and NSG, one patient required no further dressing changes and two in the SG and two in the NSG require one to two postoperative dressing changes. Six patients in both groups required three to four postoperative dressing changes. One patient in the NSG required five to six dressing changes postoperatively. On a VAS for observed wound redness, all 60 patients (100%) scored less than 1. | 0.73 No statistically significant difference |

**Conclusion**  
Suturing of arthroscopic portal wounds confers no benefit over covering the wounds with a simple dressing only. Suggested that the conservative management of these wounds confers cost benefits in both materials and time and thus may result in lower patient morbidity.

**Limitations declared by authors**  
Designed as a pilot study. A much larger study with much larger numbers would be required to show a significant difference in wound infection rates between the two groups. The recording of pain was difficult to correlate with the type of closure.

**Table 1:**  
Continued

| Methods | Prospective randomised controlled trial  
Blinded Independent observer  
Conflicts of interest- None declared  
Ethical clearance obtained  
Informed consent obtained  
Randomisation- Randomised by blinded envelope on the day of surgery to one of the two closure methods. |  
Statistical methods- The study was a pilot study and designed as a trial of equivalence. The power of the study was designed to detect a 10% difference in the outcome measures with 95% confidence and p < 0.05. The Mann–Whitney test was used to analyse nonparametric data. |

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**Patient characteristics**  
<table>
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<tr>
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</tr>
</tbody>
</table>

**Intervention**  
The arthroscopic arthrotomy incisions were less than 10mm in length. One group had portals sutured with 3/0 nylon then covered with a sterile dressing; the other group had wounds covered by a sterile dressing only.

**Outcome**  
Follow-up- No patients were lost.  
Review at 10 to 12 days postoperatively at the general practitioner’s surgery for a wound check and removal of the suture as required.  
At 3 weeks and 3 months after surgery, review at clinic by a designated, blinded, observer for cosmetic appearance. Questionnaires given for satisfaction with wound appearance and any complications.

**Outcome measures**  
<table>
<thead>
<tr>
<th>Primary outcome</th>
<th>Sutured group &amp; Non-sutured group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmetic appearance after wound healing (VAS score)</td>
<td>26 patients in the SG and 27 patients in the NSG scored between 9 and 10, comprising an excellent cosmetic result. One patient in the SG scored between 6 and 7, whereas one patient in each group scored between 7 and 8 and two patients in each group scored between 8 and 9.</td>
<td>0.66 No statistically significant difference</td>
</tr>
</tbody>
</table>

**Secondary outcomes**  
| Patient satisfaction with wound healing (VAS score) | Two slightly outlying results in both the sutured group (SG) and non-sutured group (NSG). | 0.46 No statistically significant difference |
| Pain (VAS score) | Large variation in these scores, although patients in the NSG had larger numbers scoring less pain than the SG. Authors considered that the pain scores were multi-factorial and more dependent on the nature of the arthroscopic procedure, as well as the patient’s perception of pain, rather than on the closure technique. | This was therefore not considered to contribute to the study. |
| Any complications such as infection, the number of dressing changes needed postoperatively | No signs of wound infection during any of the follow-up appointments. In both the SG and NSG, one patient required no further dressing changes and two in the SG and two in the NSG require one to two postoperative dressing changes. Six patients in both groups required three to four postoperative dressing changes. One patient in the NSG required five to six dressing changes postoperatively. On a VAS for observed wound redness, all 60 patients (100%) scored less than 1. | 0.73 No statistically significant difference |

**Conclusion**  
Suturing of arthroscopic portal wounds confers no benefit over covering the wounds with a simple dressing only. Suggested that the conservative management of these wounds confers cost benefits in both materials and time and thus may result in lower patient morbidity.

**Limitations declared by authors**  
Designed as a pilot study. A much larger study with much larger numbers would be required to show a significant difference in wound infection rates between the two groups. The recording of pain was difficult to correlate with the type of closure.
were managed with tissue adhesive tapes and in 128 patients the portals were managed by leaving wounds open covered with a simple sterile dressing. Arthroscopy portals at the knee were studied in 160 patients and at the shoulder in 160 patients. In this systematic review, evidence from one randomised controlled trial with a low risk of bias in which the shoulder joint was studied showed that there was no difference in healing of the portals (assessed by cosmetic appearance and patient satisfaction) and complications after closure with suturing or by leaving the portals open covered with a dressing. However, evidence from two randomised controlled trials with an unknown risk of bias in which the knee joint was studied showed that the best results were obtained in the group in which the portals were managed by leaving the wounds open covered with a simple sterile dressing.

Sterile adhesive tapes were studied in the knee joint in one study with an unknown risk of bias and had a better outcome than suturing, but the outcome was not as good as leaving the wounds open covered with a dressing. Further high-quality randomised controlled trials comparing this method are needed. None of the

<table>
<thead>
<tr>
<th>Bias</th>
<th>Maffulli et al</th>
<th>Sikand et al</th>
<th>Loveridge et al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection bias</td>
<td>URB</td>
<td>URB</td>
<td>LRB</td>
</tr>
<tr>
<td>Allocation concealment</td>
<td>URB</td>
<td>URB</td>
<td>LRB</td>
</tr>
<tr>
<td>Performance bias</td>
<td>URB</td>
<td>URB</td>
<td>URB</td>
</tr>
<tr>
<td>Detection bias</td>
<td>URB</td>
<td>LRB</td>
<td>LRB</td>
</tr>
<tr>
<td>Attrition bias</td>
<td>LRB</td>
<td>LRB</td>
<td>LRB</td>
</tr>
<tr>
<td>Reporting bias</td>
<td>URB</td>
<td>LRB</td>
<td>LRB</td>
</tr>
<tr>
<td>Other bias</td>
<td>URB</td>
<td>LRB</td>
<td>LRB</td>
</tr>
</tbody>
</table>

HRB, high risk of bias; LRB, low risk of bias; URB, unclear risk of bias.

Figure 1 Literature search identified 176 unique studies. Their titles and abstracts were screened by two reviewers independently for eligibility which resulted in 12 studies. The full-text articles were further assessed. Eight studies did not satisfy the inclusion criteria and there was one instance of dual/multiple publication. Three studies were finally selected for inclusion in this systematic review.


Table 3  Cosmetic appearance after wound healing

<table>
<thead>
<tr>
<th>Study</th>
<th>Assessment tool</th>
<th>Suturing</th>
<th>Leaving wounds open covered with simple sterile dressing</th>
<th>Applying sterile adhesive tape</th>
<th>p Value</th>
<th>Authors’ comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maffulli et al</td>
<td>(3-point scale)</td>
<td>2.1 ±0.81</td>
<td>1.3 ±0.4</td>
<td>0.031</td>
<td></td>
<td>Statistically significant</td>
</tr>
<tr>
<td>Sikand et al</td>
<td>Patient satisfaction with cosmetic appearance and overall healing of the wound (number of unhappy patients)</td>
<td>5 (8%)</td>
<td>0</td>
<td>0</td>
<td>Not mentioned</td>
<td>Results were best in simple dressing group followed by Steri-strip group and then suture group</td>
</tr>
<tr>
<td>Loveridge et al</td>
<td>VAS score</td>
<td>26 patients in the SG and 27 patients in the NSG scored between 9 and 10, comprising an excellent cosmetic result</td>
<td>0.66</td>
<td>No statistically significant difference</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NSG, covered only with sterile dressing/non-suturing group; SG, suturing group.

included studies demonstrated a negative or detrimental effect of leaving the portals open with a dressing.

It was also evident that there was no difference in pain at the arthroscopic portal site after closing with three techniques, supported by all three studies.3–5

All three included studies3–5 proposed that leaving the wound without suturing would help in draining the blood and prevent subcutaneous haematoma formation which in turn reduces swelling, redness and subsequent infection.

Evidence from the three studies showed that suturing of arthroscopic portal wounds confers no benefit over leaving them open covered with a simple dressing. The suturing technique requires health professional time for their removal during follow-up, which can also be painful.4 5 The risk of needlestick injury is decreased by leaving the wound open covered with a simple dressing.3

The studies concluded that managing arthroscopic portals by leaving them open covered with just a dressing was safe, cost effective and time saving.3–5 Sterile adhesive tapes were used in only one study and were found to be less desirable than leaving wounds open covered with a dressing but better than suturing.4 5

The evidence from the three studies included in this review is also supported by other studies in the literature.

Patil et al44 in their quasi-randomised study concluded that managing a normal sized arthroscopic portal with a simple sterile dressing had an advantage over suturing the portals and had high patient satisfaction with the appearance of their wounds, time and money saving. They also propose that leaving portals open would decrease the tourniquet time which, in turn, can minimise the complications related to the tourniquet. The cost of the procedure would be saved because of less operative time, savings on the cost of suture material and no need for health personnel to later remove sutures during follow-up. It was also stated that the risk of needlestick injury and the resulting complications was minimised by leaving portals open with just a dressing.

Hussein and Southgate10 in a non-randomised comparative study compared adhesive tape or leaving portals open just with a dressing for knee arthroscopic portal wounds. They concluded that leaving knee arthroscopy wounds open was an acceptable method of management compared with adhesive tape. Leaving the wound open saves time both in the theatre and in outpatients. They reported that the method chosen for wound management following knee arthroscopy seems to be of less importance and unobstructed healing is the rule. Suturing of the wounds is not necessary, and use of sterile adhesive tape or leaving the wounds open is adequate.

Bhattacharya and Bradley35 in their non-randomised comparative study compared closing knee arthroscopic portal wounds with nylon suturing or closure with sterile adhesive tapes. They concluded that the wound closure strips were an effective, safe, cosmetically satisfactory, cost-effective and time-saving alternative to conventional suture materials for skin closure after arthroscopy.

In a non-randomised comparative study, Fairclough and Moran44 compared interrupted nylon sutures and sterile adhesive tapes for the closure of knee arthroscopic portals. There was no difference in terms of wound healing between the two methods. Closing portals using sterile adhesive tape was cost-effective, time-saving and caused less discomfort during its removal. It was effective and convenient for wound management.

Stavrou et al16 in a prospective crossover study compared a single nylon suture or sterile adhesive tapes for ankle arthroscopy portals. They concluded that the use of either a single suture or sterile adhesive tapes in the closure of ankle arthroscopy portals had equivalent results. Both methods were safe with equivalent cosmetic results and low infection rates.

Table 4  Patient satisfaction with wound healing

<table>
<thead>
<tr>
<th>Study</th>
<th>Assessment tool</th>
<th>Suturing</th>
<th>Leaving wounds open covered with simple sterile dressing</th>
<th>Applying sterile adhesive tape</th>
<th>p Value</th>
<th>Authors’ comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sikand et al</td>
<td>Patient satisfaction with cosmetic appearance and overall healing of the wound (number of unhappy patients)</td>
<td>5 (8%)</td>
<td>0</td>
<td>0</td>
<td>Not mentioned</td>
<td>Results were best in simple dressing group followed by Steri-strip group and then suture group</td>
</tr>
<tr>
<td>Loveridge et al</td>
<td>VAS score</td>
<td></td>
<td>The vast majority were very happy with their scar, with 25 in both groups scoring between 9 and 10</td>
<td>0.46</td>
<td>No statistically significant difference</td>
<td></td>
</tr>
</tbody>
</table>

Faraj et al\cite{Faraj2017} compared five different methods of knee arthroscopy portal closure: suturing with interrupted non-absorbable sutures, suturing with interrupted absorbable sutures, suturing with subcuticular absorbable sutures, applying sterile adhesive tapes and leaving wounds open. They concluded that knee arthroscopy portals can be left open with no apparent increase in complication rate and high patient satisfaction with the appearance of their wounds. It would also save time and money.

Only one study compared tissue adhesive with suturing in knee arthroscopy, which concluded that the use of liquid adhesive in knee arthroscopy is safe and achieves comparable results to nylon sutures in the short term.\cite{Sikand2014} This was a retrospective comparative study (clinical audit). No randomised control studies using this method have been carried out.

There is evidence that using tissue adhesives generates cost savings compared with suturing owing to the shorter time for wound closure and no need for a postoperative outpatient visit.\cite{Loveridge2017}

### Strengths of systematic review

This review had a clearly defined protocol. A clear review question was formulated by using the PICOS format.

In this systematic review, the inclusion and exclusion criteria were clear and precise. There was no time limitation in the eligibility criteria, which has helped in the wider search for all the published literature, reducing chances of missing studies and thus reducing selection bias.

Two independent reviewers were involved in study selection, data extraction and quality assessment of each study, minimising selection and reporting bias. This minimises the element of subjectivity.

A comprehensive database search was undertaken to identify all the existing published studies to avoid publication bias.\cite{Maffulli2016}

Studies included were randomised controlled trials, which are level 1b evidence considered as the higher methodological quality.\cite{32,33} Randomised controlled trials are the best evidence available to determine whether a cause-effect relation exists between treatment and outcome.\cite{32,33} Most of the trials had well-defined inclusion and exclusion criteria.

During this review there was no conflict of interest and no funding or sponsorship was received, which decreases the possibility of bias and increases the reliability of the results.

### Limitations of systematic review

This systematic review included only three randomised controlled trials, which were not enough to do a meta-analysis, so a full estimate of effect size cannot be given in this review.\cite{Sherman2016}

All the included studies were pilot studies with a small sample size, which may produce imprecise results with a wide CI.\cite{Loveridge2017}

All the studies were carried out in the UK, resulting in no international representation which affects the generalisability to the world population. There is a need for randomised controlled trials representing all parts of the world with a large sample size representing the whole population, better randomisation, treatment concealment and blinding to achieve a better level of evidence.

None of the included studies mentioned the baseline characteristics of the study population such as age, medical comorbidities and pre-existing joint problems. There is no mention of whether intervention groups were matched.

Sherman et al\cite{Sherman2016} stated that the procedure undertaken inside the joint through arthroscopy should also be considered when interpreting outcomes. The actual procedure undertaken inside the joint by arthroscopy was not discussed, and the size of the arthroscopy portals and suture materials used were not clearly defined.

The risk of needlestick injury with the suturing technique was not assessed in any of the included studies. A study reported that the risk of needlestick injury and resulting complications was minimised by leaving portals open with just a dressing.\cite{34}

### Table 5 Pain at arthroscopy portal site\cite{Sikand2014}

<table>
<thead>
<tr>
<th>Study</th>
<th>Assessment tool</th>
<th>Suturing</th>
<th>Leaving wounds open covered with simple sterile dressing</th>
<th>Applying sterile adhesive tape</th>
<th>p Value</th>
<th>Authors' comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sikand et al\cite{Sikand2014}</td>
<td>VAS score</td>
<td>17</td>
<td>8</td>
<td>9</td>
<td>0.37</td>
<td>No statistically significant difference</td>
</tr>
</tbody>
</table>

### Table 6 Complications such as infection, redness or swelling\cite{Maffulli2016}

<table>
<thead>
<tr>
<th>Study</th>
<th>Assessment tool</th>
<th>Complications</th>
<th>Suturing</th>
<th>Leaving wounds open covered with simple sterile dressing</th>
<th>Applying sterile adhesive tape (Steri-strips)</th>
<th>p Value</th>
<th>Authors' comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maffulli et al\cite{Maffulli2016}; minor complications</td>
<td>No of patients with complication</td>
<td>Haematoma</td>
<td>5</td>
<td>3</td>
<td>0.042</td>
<td>Statistically significant difference in favour of sutureless technique</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superficial abscess</td>
<td>4</td>
<td>1</td>
<td>0.038</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blood seepage</td>
<td>13</td>
<td>25</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cross-hatching at wound</td>
<td>6</td>
<td>0</td>
<td>Not mentioned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sikand et al\cite{Sikand2014}</td>
<td>No of patients with complication</td>
<td>Swelling</td>
<td>18 (29%)</td>
<td>6 (12%)</td>
<td>5 (11%)</td>
<td>0.02</td>
<td>Statistically significant difference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Redness</td>
<td>23 (37%)</td>
<td>4 (9%)</td>
<td>12 (23%)</td>
<td>0.004</td>
<td>Statistically significant difference. The suturing group had significantly more redness</td>
</tr>
<tr>
<td>Loveridge et al\cite{Loveridge2017}</td>
<td>No of patients with complication</td>
<td>Redness</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>0.73</td>
<td>No statistically significant difference</td>
<td></td>
</tr>
</tbody>
</table>
The suture materials used when closing arthroscopic portals can act as confounding factors. There is a need for randomised controlled trials comparing different suture materials for arthroscopic portal closure.

Implications
The evidence from this systematic review can be used for further studies comparing different methods of arthroscopic portal closure. There is a need for further well-designed randomised controlled trials studying sterile adhesive tapes for the closure of arthroscopic portals.

Clinical practice is also linked to cost effectiveness. Further research is needed with detailed cost analysis.

The evidence reported by this systematic review helps in informing surgeons about better closure methods for arthroscopic portal wounds. Findings from this review might encourage surgeons to adopt these techniques and future practice can be based on this evidence.

CONCLUSION
This systematic review suggests that managing arthroscopic portals by leaving wounds open covered with a simple sterile dressing or by applying sterile adhesive tape can be a safe alternative technique to suturing. This evidence is based on three randomised controlled studies with level 1b evidence, considered as higher methodological quality. Among the included studies, one study had a low risk of bias and the other two had an unclear risk of bias.

In view of the limited number of studies and the limited number of participants, it is not possible to strongly recommend any one method of arthroscopic portal closure. There is a need for randomised controlled trials comparing different methods of arthroscopic portal closure with a larger sample size, representing different populations, multicentred, with better methodological quality, outcome measures and detailed cost analysis.

Correction notice This article has been corrected since it was published Online First. The correspondence address has been updated.

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Contributors CMD contributed to writing the protocol for the review, literature review, abstracting data, synthesis of results and manuscript writing. MK and AJJS contributed by supervising. AK reviewed and CMD contributed by manuscript writing. GSR and DB edited the manuscript. All the authors read and approved the final version of the manuscript being submitted.

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