



Percutaneous versus open pedicle screw fixation for treatment of thoracolumbar fractures: Systematic review and meta-analysis of comparative studies



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ABSTRACT

Background: The main aims of managing thoracolumbar fractures involve stabilization of traumatized regions, to promote vertebral healing or segmental fusion. Recently, percutaneous pedicle screw fixation has evolved as an alternative approach for the treatment of thoracolumbar fractures, aiming to minimize soft tissue injury and perioperative morbidity. A systematic review and meta-analysis was conducted to compare outcomes of percutaneous versus open pedicle screw fixation for thoracolumbar fractures.

Methods: Relevant articles were identified from six electronic databases from their inception to December 2014.

Results: From 12 relevant studies identified, 279 patients undergoing percutaneous fixation were compared with 340 open fixation procedures. Operative duration was significantly shorter in the percutaneous group by 19 min ($P=0.0002$). The percutaneous approach was also associated with shorter hospital stay by 5.7 days ($P=0.0007$). Whilst there was no difference in screw malpositioning (RR, 0.77; 95% CI, 0.33, 1.83; $P=0.56$), the percutaneous approach had lower rates of infections (RR, 0.36; 95% CI, 0.13, 1.00; $P=0.05$), and superior visual analogue scale clinical outcomes ($P=0.001$). No difference was found between the groups in terms of postoperative Cobb angle ($P=0.22$), postoperative body angle ($P=0.66$), and postoperative anterior body height ($P=0.19$).

Conclusions: The percutaneous approach was associated with shorter operative duration and hospital stay, reduced intraoperative blood loss and reduced infection rates. Given the lack of robust clinical evidence, these findings warrant verification in large prospective registries and randomized trials.

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1. Introduction

Thoracolumbar fractures are the most common fractures of the spinal column, accounting for over 160,000 injury cases per year [12]. Thoracolumbar fractures are often caused by high-energy impact injuries, including motor vehicle accidents and falls, and can lead to pain, deformity and loss of function [6,7,16]. Traditionally, surgical intervention for thoracolumbar fractures involves open exposure, however, this has been associated with significant perioperative complications including blood loss, infections and long hospitalization [20].

Recently, minimally invasive percutaneous pedicle screw fixation has been introduced as an alternative approach for the treatment of thoracolumbar fractures, aiming to minimize soft tissue injury and perioperative morbidity [11,26]. Percutaneous pedicle screw fixation systems were originally in the realm of degenerative spinal disease, and have been shown to be effective in avoiding tissue and muscle disruption, whilst shortening hospital and recovery duration, reducing blood loss and complications [17,18]. Whilst similar advantages have also been shown for treatment of thoracolumbar fractures in some reports, the evidence is mainly limited to low-grade, inadequately powered observational studies [3,14,27,31]. Furthermore, long-term outcomes of percutaneous pedicle screw fixation for thoracolumbar fractures has not been well established, further limiting the evidence available for this technology.

In order to address limitations in the evidence, a systematic review and meta-analysis of comparative studies was conducted

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to evaluate clinical, functional and radiological outcomes of percutaneous versus open pedicle screw fixation for thoracolumbar fractures.

2. Methods

2.1. Literature search strategy

Systematic literature searches were performed in six electronic databases, including Ovid Medline, PubMed, Cochrane Central Register of Controlled Trials (CCTR), Cochrane Database of Systematic Reviews (CDSR), American College of Physicians (ACP) Journal Club, and Database of Abstracts of Review of Effectiveness (DARE) from their date of inception to December 2014. To achieve the maximum sensitivity of the search strategy, we combined the terms: (“percutaneous” OR “open” OR “pedicle screw” OR “Sextant” OR “minimally invasive” AND (“thoracolumbar fracture” OR “lumbar fracture”)) as either key words or MeSH terms. The reference lists of all retrieved articles were reviewed for further identification of potentially relevant studies, assessed using the inclusion and exclusion criteria.

2.2. Selection criteria

Eligible comparative studies for the present systematic review and meta-analysis included those in which patient cohorts comparing percutaneous versus open pedicle screw instrumentation approaches for treatment of thoracolumbar fractures. When institutions published duplicate studies with accumulating numbers of patients or increased lengths of follow-up, only the most complete reports were included for quantitative assessment at each time interval. Reference lists were also hand-searched for further relevant studies. All publications were limited to those involving human subjects and in the English language. Abstracts, case reports, conference presentations, editorials, reviews and expert opinions were excluded.

2.3. Data extraction and critical appraisal

The primary outcome of interest included, operative, radiographic and clinical outcomes. Operative outcomes comprised operation duration, intraoperative bleeding, postoperative bleeding, hospital stay; radiographic outcomes comprised postoperative Cobb angle, postoperative body angle, postoperative anterior vertebral height; clinical outcomes comprised visual analogue scale (VAS) for back pain. Postoperative complication endpoints included screw malpositioning, infections, and postoperative death. When exact mean and standard deviations (SD) were not reported, these values were estimated from available graphs. All data were extracted from article texts, tables and figures. Two investigators independently reviewed and assessed the quality of each retrieved article. Discrepancies between the reviewers were resolved by discussion and consensus.

2.4. Statistical analysis

Clinical outcomes were assessed using standard meta-analysis techniques, with the relative risk (RR) or weighted mean difference (WMD) used as a summary statistic. Both fixed- and random-effect models were tested and used to calculate the RR or WMD for the surgical literature. Since similar results were obtained, only results of the random-effect model are presented. χ^2 tests were used to study heterogeneity between trials. I^2 statistic was used to estimate the percentage of total variation across studies, owing to heterogeneity rather than chance, with values greater than 50% considered as substantial heterogeneity. Publication bias

was assessed using the funnel plot method. All P values were 2-sided. All statistical analysis was conducted with Review Manager Version 5.3.1 (Cochrane Collaboration, Software Update, Oxford, United Kingdom).

3. Results

3.1. Literature search

The literature search from six electronic databases identified 179 articles. After application of the inclusion and exclusion criteria, 12 comparative studies were finally included in the present systematic review and meta-analysis (Table 1). There were two randomized studies [14,28] and 10 observational studies included [3,8,9,13,15,27,29–32]. Of the 12 studies, there were seven prospective studies [8,9,14,28–31] and five retrospective studies [3,13,15,27,32]. A total of 279 patients who underwent percutaneous instrumentation were compared with 340 patients who underwent conventional open instrumentation. In all studies, thoracolumbar fractures were the primary indication for percutaneous pedicle screw fixation. Follow-up for the included studies ranged from 9 [9] to 60 [32] months. Baseline characteristics of the included studies are summarized in Supplementary Table 1.

3.2. Operative parameters

Operative duration for percutaneous and open procedures was reported in all 12 included studies. The percutaneous cohort had significantly shorter operative duration compared to the open cohort (WMD, -18.83 min; 95% CI, -28.72 , -8.94 ; $I^2 = 88\%$; $P = 0.0002$). Significant heterogeneity was detected for this outcome ($P < 0.00001$) (Fig. 1).

Incision size was significantly smaller in the percutaneous group compared to open fixation group (WMD, -3.88 cm; 95% CI, -5.03 , -2.72 ; $I^2 = 86\%$; $P < 0.00001$).

Intraoperative bleeding was significantly lower in the percutaneous fixation cohort versus open fixation (WMD, -285.44 mL; 95% CI, -354.56 , -216.32 ; $I^2 = 98\%$; $P < 0.00001$) (Fig. 2). Similar trends were also seen for postoperative bleeding, which was significantly lower in the percutaneous cohort (WMD, -335.70 mL; 95% CI, -423.19 , -248.21 ; $P < 0.00001$).

Hospital stay was reported in six included studies (Fig. 3). Hospital stay was significantly shorter in the percutaneous fixation group compared to open fixation (WMD, -5.72 days; 95% CI, -9.01 , -2.43 ; $I^2 = 97\%$; $P = 0.0007$).

3.3. Complications

The primary complications reported in common amongst the studies were screw malpositioning and infection rates. Screw malpositioning rates were reported in 10 included studies. No difference was found in terms of screw malpositioning between percutaneous versus open pedicle screw fixation approaches (3.0% versus 4.2%; RR, 0.77; 95% CI, 0.33, 1.83; $I^2 = 0\%$; $P = 0.56$). Infection rates were reported in 11 included studies. Infection rates were demonstrated to be significantly lower in the percutaneous fixation cohort, with 1 complication in the percutaneous group versus 12 total infections in the open fixation cohort (0.3% versus 3.4%; RR, 0.36; 95% CI, 0.13, 1.00; $I^2 = 0\%$; $P = 0.05$) (Fig. 4). No deaths attributed to percutaneous or open pedicle screw fixation were reported in the included studies.

3.4. Clinical outcomes

Postoperative VAS outcomes for back pain were reported in six studies. Across all studies, for both groups, there was

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