Reamed versus nonreamed intramedullary nailing of lower extremity long bone fractures: a systematic overview and meta-analysis

Bhandari M, Guyatt G H, Tong D, Adli A, Shaughnessy S G

Authors' objectives
To determine the effect of reamed versus nonreamed intramedullary (IM) nailing of lower extremity long bone fractures, on the rates of nonunion, implant failure, malunion, compartment syndrome, pulmonary embolus and infection.

Searching
MEDLINE was searched from 1969 to 1998 to identify: the population, i.e. tibial fracture or femoral fracture; the intervention, i.e. fracture fixation and intramedullary and reamed; and the methodology, i.e. clinical trial.

Two authors noted frequently cited articles then conducted a search of the Science Citation Index to locate other articles that may have cited them.

Additional studies were located by handsearching four major orthopaedic journals from 1966 to January 1998, two bibliographies of major orthopaedic texts, and the titles of presentations and posters at three major orthopaedic meetings, by examining the authors' personal files, and by contacting two experts.

Study selection
Study designs of evaluations included in the review
Prospective, randomised controlled trials (RCTs) or pseudo-randomised controlled trials were included.

Specific interventions included in the review
Reamed versus nonreamed IM nailing.

Participants included in the review
Patients with lower extremity long bone fractures (tibia or femur).

Outcomes assessed in the review
The primary outcome measure was the rate of nonunion, i.e. failure of fracture to unite more than 6 months post-operatively, with radiographic evidence of fracture line or pain at the fracture site and inability to bear full weight. Fractures that required secondary procedures, such as revision IM nailing or bone grafting, to achieve union were also considered nonunions.

Secondary outcome measures were: frequency of implant failure (breakage of nail or interlocking screws), malunion (more than 5 degrees of angulation, more than 10 degrees of rotation, more than one centimetre of shortening), compartment syndrome (increased pain, tense swelling, paraesthesias, and pain with passive extension or a documented increase in compartment pressures), pulmonary complications (venous or fat embolism), and infection rates.

How were decisions on the relevance of primary studies made?
Three of the authors independently performed the selection of studies for the review. The review of the complete articles included only the methods section, and was thus blinded to author, institution, journal and results.

The weighted kappa and intraclass correlation coefficient were used to check agreement between reviewers for the titles, abstracts and methods sections of the included studies. An a priori criterion of a k-score of 0.65 or greater was chosen for adequate agreement.

Assessment of study quality
Studies were rated with respect to:

1. Randomisation and blinding.
3. Follow-up.
4. Statistical analysis.

In addition, a 21-point study quality assessment scale provided a further rating of methodological quality (see Other Publications of Related Interest no.1). Three of the authors independently performed the assessment of study quality.

Data extraction
Three of the authors independently performed the data extraction, and any disagreements were resolved by consensus. Data were extracted from each relevant article on the population, intervention and outcomes.

Methods of synthesis
How were the studies combined?
Pooled relative risks (RRs) with 95% confidence intervals (CIs) were calculated using the random-effects model of DerSimonian and Laird (see Other Publications of Related Interest no.2).

The authors also calculated the number-needed-to-treat (NNT).

How were differences between studies investigated?
The consistency, or homogeneity, of the estimates across studies was tested according to the method of Breslow and Day (see Other Publications of Related Interest no.3).

Heterogeneity was also assessed using sensitivity analyses to examine differences in study populations (the degree of soft tissue injury, i.e. open versus closed fractures), the type of bone (tibia versus femur), or differences in methodological features (methodological quality scores, completeness of follow-up, or whether studies were published or unpublished).

Results of the review
Nine RCTs with 646 participants were included in the review; of these, 5 contained unpublished data.

The kappa-score for study selection was 0.88 (95% CI: 0.82, 0.94).

The intraclass correlation score for quality assessment was 0.89 (95% CI: 0.73, 0.99). The Pearson correlation was 0.91 (p=0.08). Kappa agreement ranged from 0.67 to 1.0 for components of study design, for example: randomisation and blinding; population, intervention and outcomes; statistical analysis; and follow-up.

The pooled RR of reamed versus nonreamed IM nailing was 0.33 (95% CI: 0.16, 0.68, p=0.0019).

The absolute risk difference in nonunion rates with reamed IM nailing was 7% (95% CI: 1, 11). Thus, one nonunion could be prevented for every 14 patients treated with IM nailing (NNT 14.28).

The RR for implant failure was 0.30 (95% CI: 0.16, 0.58, p<0.001).

The RR for malunion was 1.06 (95% CI: 0.32, 3.57).

The RR for pulmonary embolus was 1.10 (95% CI: 0.26, 4.76).

The RR for compartment syndrome was 0.45 (95% CI: 0.13, 1.56).
The RR for infection was 0.98 (95% CI: 0.21, 4.76).

Sensitivity analysis suggested that reported rates of nonunion and implant failure were higher in studies of lower quality. The type of long bone fracture (tibia or femur), the degree of soft tissue injury (open or closed), study quality, percentage follow-up, and whether a study was published or unpublished, did not significantly alter the relative risk of nonunion between reamed and nonreamed IM nailing.

Secondary outcomes (4 trials): reamed IM nailing did not incur greater risks of malunion, pulmonary emboli, compartment syndrome or infection. CIs were wide and crossed equivalence points.

**Authors' conclusions**
The authors state that there is evidence from this review that reamed IM nailing of lower extremity long bone fractures significantly reduces rates of nonunion and implant failure, in comparison with nonreamed nailing.

**CRD commentary**
This is a very good systematic review. The authors have stated the research question clearly, as well as their predetermined inclusion and exclusion criteria. The literature search was quite thorough but should have searched more than one database. The search sought unpublished and expert information on the topic, but does not state whether there were any language restrictions.

The quality of the included studies was assessed, and the authors have reported how the articles were selected and who performed the selection, quality assessment, and data extraction. Agreement on study selection was also statistically assessed.

The data extraction was reported in tables and discussed in the text of the review. There are errors in reporting of results between the body of the review and the abstract. The studies were statistically combined, and heterogeneity was assessed and taken into account when reporting the results. Further sensitivity analyses were performed to evaluate the effects of study and patient characteristics on the results of the meta-analysis. The authors' conclusions appear to follow from the results, and the authors have plans to investigate these conclusions in further randomised studies.

**Implications of the review for practice and research**
Practice: The authors state that, in practice, based on this overall analysis, reamed IM nailing of lower extremity long bone fractures will yield more or less the same result in a variety of fracture morphologies.

Research: The authors state that additional research is needed, and that they are currently developing a protocol and recruiting centres for a large, multicentre randomised trial, to improve the precision of the current estimate of the effect of reamed IM nailing of lower extremity long bone fractures on clinical outcomes.

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**Other publications of related interest**

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