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Topical NSAIDs for acute pain: a meta-analysis

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Abstract

Background: A previous systematic review reported that topical NSAIDs were effective in relieving pain in acute conditions like sprains and strains, with differences between individual drugs for efficacy. More trials, a better understanding of trial quality and bias, and a reclassification of certain drugs necessitate a new review.

Methods: Studies were identified by searching electronic databases and writing to manufacturers. We selected randomised double blind trials comparing topical NSAID with either placebo or another active treatment in adults with acute pain, and extracted dichotomous information approximating to a 50% reduction in pain at one week, together with details of adverse events and withdrawals. Relative benefit and number-needed-to-treat (NNT), and relative risk and number-needed-to-harm (NNH) were calculated, with sensitivity analyses where appropriate to investigate differences between individual drugs and aspects of trial design.

Results: Twenty-six double blind placebo controlled trials had information from 2,853 patients for evaluation of efficacy. Topical NSAID was significantly better than placebo in 19 of the 26 trials, with a pooled relative benefit of 1.6 (95% confidence interval 1.4 to 1.7), and NNT of 3.8 (95% confidence interval 3.4 to 4.4) compared with placebo for the outcome of half pain relief at seven days. Results were not affected by outcome reported, or condition treated, but smaller trials yielded a larger estimate of efficacy. Indirect comparisons of individual topical NSAIDs showed that ketoprofen was significantly better than all other topical NSAIDs, while indomethacin was barely distinguished from placebo. Three trials, with 433 patients, compared topical with oral NSAID (two trials compared the same drug, one compared different drugs) and found no difference in efficacy. Local adverse events, systemic adverse events, or withdrawals due to an adverse event were rare, and no different between topical NSAID and placebo.

Conclusions: Topical NSAIDs were effective and safe in treating acute painful conditions for one week.

Background

A systematic review of topical NSAIDs, conducted by this

research group in 1996, reported that they were effective in relieving pain in acute conditions like sprains and

strains [1]. Number-needed-to-treat (NNT), the number of patients that need to be treated for one to benefit from a particular drug, who would not have benefited from placebo, was used to estimate efficacy, and for all topical NSAIDs pooled together the NNT at one week was 3.9 (95% confidence interval (CI) 3.4 to 4.4). There were differences between individual topical NSAIDs, with indomethacin being no different from placebo, while ketoprofen (NNT 2.6), felbinac (NNT 3.0), ibuprofen (NNT 3.5) and piroxicam (NNT 4.2) were all significantly better than placebo.

There are three reasons why an updated review of topical NSAIDs in acute pain is needed. First, we have a better appreciation of factors that can introduce bias [2-4], and would not now accept trials that were not double blind, or were very small. Second, topical salicylate and benzydamine are no longer classed as topical NSAIDs [5]. Thirdly, there are now more trials. We believed that updating the review would provide more accurate efficacy estimates for topical NSAIDs, with a prior intent to determine efficacy for individual drugs.

Methods

Searching

Relevant studies were sought regardless of publication language, type, date or status. Studies included in the previous review were examined for inclusion in this updated version, according to our inclusion criteria. The Cochrane Library, MEDLINE and PreMedline, EMBASE and PubMed were used to find relevant studies published since the last review, for the years 1996 to April 2003. Reference lists of retrieved articles were also searched. The search strategy included "application: topical" together with "cream", "gel" etc, together with generic names of NSAIDs, and proprietary preparations of topical treatment in which the principal active ingredient was an NSAID [6,7] (see Additional file 1: search strategy). Twenty pharmaceutical companies in the UK, 66 in Europe, and two in North America, known to manufacture topical NSAIDs, were sent letters asking if they could supply papers.

Selection

We identified reports of randomised, double-blind, active or placebo-controlled trials in which treatments were administered to adult patients with acute pain resulting from any strains, sprains or sports injuries. Excluded conditions were oral, ocular or buccal diseases. Application of treatment had to be at least once daily. At least ten patients had to be randomised to a treatment group. Outcomes closest to seven days were extracted.

Quality and validity assessment

Trial quality was assessed using a validated three-item scale with a maximum quality score of five [8]. Included studies had to score at least two points, one for randomisation and one for blinding. A sixteen-point scale was used to assess trial validity [9].

Data abstraction

Quality and validity assessments were made independently by at least two reviewers. Extracted outcomes were verified by one other reviewer. Disputes were settled by discussion between all reviewers.

Outcomes

We defined our own outcome of clinical success, representing approximately a 50% reduction in pain [1]. This was either the number of patients with a "good" or "excellent" global assessment of treatment, or "none" or "slight" pain on rest or movement (or comparable wording) measured on a categorical scale. A hierarchy of outcomes was used to extract efficacy information, shown below in order of preference:

- 1) number of patients with a 50% or more reduction in pain
- 2) patient reported global assessment of treatment
- 3) pain on movement
- 4) pain on rest or spontaneous pain
- 5) physician or investigator global assessment of treatment

In addition, the number of patients showing undefined "improvement" was also accepted.

Secondary outcomes were extracted from included papers that reported them. These were the number of patients (i) reporting one or more local adverse event (itching, stinging, rash), (ii) reporting one or more systemic adverse event (iii) withdrawing from trials due to adverse events.

Quantitative data synthesis

The number of patients randomised into each treatment group (intention to treat) was used in the efficacy analysis. Information was pooled for the number of patients in each trial achieving at least 50% pain relief, or similar measure, for both topical NSAID and control. These were used to calculate NNT with a 95% confidence interval (CI) [10]. Relative benefit and relative risk estimates with 95% CIs were calculated using the fixed effects model [11]. A statistically significant benefit of topical NSAID over control was assumed when the lower limit of the 95% CI of

the relative benefit was greater than one. A statistically significant benefit of control over active treatment was assumed when the upper limit of the 95% CI was less than one. Number-needed-to-harm (NNH) and relative risk were calculated for these outcomes in the same way as for NNTs and relative benefit. Homogeneity of trials was assessed visually [12-14]. All calculations were performed using Microsoft Excel X for the Macintosh and RevMan 4.2. In sensitivity analyses the z test was used [15]. QUOROM guidelines were followed [16].

Sensitivity analysis

Our prior intention was to perform sensitivity analyses on pooled outcomes using the z test in terms of quality score (less than 2 versus 3 or more), validity score (less than 8 versus 9 or more), size (less than 40 patients per group versus 40 or more, the median in a previous meta-analysis [1]), outcome type (higher versus lower preference outcomes), and particular NSAID used. At least three studies had to be available in any of these different contexts before information was pooled.

Results

Study characteristics

Ten out of the 20 UK companies, and two out of 66 European companies that we contacted replied to our request for studies. However, only three companies supplied us with useful material; either published studies or bibliographies. One company supplied material that was unpublished at the time of writing [17].

We identified 89 potential papers from our searches. Fifty-three were excluded (see Additional file 2: studies excluded from the review, Additional file 3: QUOROM flow diagram). Of the original 89, 64 papers were in the previous review, of which we excluded 30; four placebo and 15 active controlled trials used salicylates, four placebo controlled trials used benzydamine, two were single blind, and one each had inappropriate randomisation, did not state dose or duration of treatment, had no useable data, used mixed pain conditions including some chronic conditions, or had an inappropriate add-on design. There were 25 potential papers not in the previous review. Of these, 23 were excluded because they were not randomised (9), had no useable data (4), were not double blind (3), were experimental (2), or for other reasons (5).

Thirty-six trials met the selection criteria; 34 from the previous review and two new ones. Twenty-four trials [17-40] had only placebo controls, eight [41-48] only active controls, and four [49-52] had both placebo and active controls. Of the 12 active controlled trials, nine compared one topical NSAID with a different topical NSAID, and three [44,48,49] used oral NSAID controls. Details of all included studies with outcomes and quality and validity

scores are in Additional files 4 (Outcome details of placebo-controlled trials) and 5 (Outcome details of active-controlled trials). Information about patients was limited, though age ranges were given. Patients had mainly sports injuries, soft tissue injuries, or sprains and strains.

Quality scores were high, with 24/28 placebo controlled and 11/12 active controlled trials scoring 3 or more points out of a maximum of 5. Validity scores were also high, with 25/28 placebo controlled and 10/12 active controlled trials scoring 9 or more out of a maximum of 16 (see Additional files 4 and 5).

Placebo controlled trials

Efficacy

Twenty-six trials with information from 2,853 patients were analysed for efficacy. In 19 of the 26 trials topical NSAID was significantly better than placebo, with a lower confidence interval of the relative benefit above 1 in our analysis. Topical NSAIDs as a class were significantly better than placebo, with relative benefit 1.6 (95% CI 1.4 to 1.7) and NNT 3.8 (3.4 to 4.4) (Table 1). Mean response rate with placebo was 39% and varied from 8% to 75% in individual trials. Mean response rate with topical NSAID was 65%, varying from 41% to 100% in individual trials (Figure 1).

Sensitivity analyses could not be done for higher versus lower quality or validity scores, because there were few studies of lower quality (2/5 on the quality scale) or lower validity (8/16 or less on the validity scale). Analysis limited to only higher quality or higher validity trials, or trials of both higher quality and higher validity, produced no difference in the efficacy measure (Table 1). The median group size for topical NSAID was 41. There was a significantly better (lower) NNT in trials with fewer than 40 patients in each treatment arm than in those with 40 patients or more ($z = 3.3$, $p = 0.001$). Outcomes of undefined improvement and physician rated global outcomes gave the same NNT as our preferred outcomes of patient rated global or pain on movement/spontaneous pain.

Efficacy estimates were also made for five individual drugs studied in at least three trials (Table 1). The five topical NSAIDs were all significantly better than placebo, but in the case of indomethacin just so. Ketoprofen had the lowest (best) NNT of 2.6 (2.2 to 3.3). The result for ketoprofen was significantly better than for ibuprofen ($z = 2.2$, $p = 0.03$), felbinac ($z = 2.1$, $p = 0.03$), piroxicam ($z = 3.0$, $p = 0.003$) and indomethacin ($z = 4.5$, $p < 0.00006$).

Harm

There was no statistically significant difference between the numbers of patients experiencing one or more local adverse events (4%), one or more systemic adverse events

Table 1: Summary data and sensitivity analyses for placebo controlled trials

Parameter	Trials	Patients	Success with		Relative benefit (95% CI)	NNT (95% CI)
			treatment	placebo		
All trials	26	2853	993/1531	512/1322	1.6 (1.4 to 1.7)	3.8 (3.4 to 4.4)
Trial quality						
Quality score ≥3/5	23	2551	893/1375	443/1176	1.6 (1.5 to 1.8)	3.7 (3.2 to 4.3)
Validity score ≥9/16	24	2793	969/1501	508/1292	1.5 (1.4 to 1.7)	4.0 (3.5 to 4.6)
Quality score ≥3 and validity score ≥9	22	2511	876/1355	440/1156	1.6 (1.4 to 1.8)	3.8 (3.3 to 4.4)
Trial size						
≥40 patients per group	15	2279	761/1234	400/1045	1.4 (1.3 to 1.6)	4.3 (3.7 to 5.2)
<40 patients per group	11	574	232/297	112/277	1.9 (1.6 to 2.2)	2.7 (2.2 to 3.3)
Efficacy by outcome type						
preferred outcomes	17	1941	676/1025	373/916	1.5 (1.3 to 1.6)	4.0 (3.4 to 4.8)
lower preference outcomes	9	912	317/506	139/406	1.7 (1.5 to 2.1)	3.5 (2.9 to 4.5)
Efficacy by topical NSAID						
ketoprofen	6	517	203/261	101/256	2.1 (1.7 to 2.5)	2.6 (2.2 to 3.3)
ibuprofen	5	365	112/183	67/182	2.0 (1.5 to 2.6)	4.1 (2.9 to 6.9)
felbinac	3	413	112/210	57/203	1.6 (1.2 to 2.2)	4.0 (2.9 to 6.2)
piroxicam	3	563	179/283	118/280	1.4 (1.1 to 1.7)	4.7 (3.4 to 7.7)
indomethacin	3	394	95/197	76/197	1.3 (0.99 to 1.6)	10 (5.2 to infinity)
Adverse events						NNH 95% CI
Local adverse events	23	2741	65/1464	60/1277	1.6 (1.0 to 2.5)	Not calculated
Systemic adverse events	23	2685	40/1437	30/1248	1.4 (0.9 to 2.0)	Not calculated
Adverse events withdrawals	24	3011	13/1601	10/1410	1.6 (0.8 to 3.4)	Not calculated

(2.5%), or the numbers of patients withdrawing due to an adverse event (0.8%), with topical NSAIDs than with placebo (Table 1). For systemic adverse events, 56 of the 70 events recorded occurred in a single trial [27], and the rate of systemic adverse events excluding this trial was below 1%. Systemic adverse events and adverse event withdrawals did not differ between topical and oral NSAID.

Active controlled trials

Three trials, with 433 patients, compared a topical NSAID with an oral NSAID (indomethacin 75 mg daily in one trial and ibuprofen 1,200 mg daily in two). One trial [44] compared different topical and oral NSAIDs (felbinac foam with oral ibuprofen), while the other two com-

pared the same topical and oral NSAID, ibuprofen in one [48] and indomethacin in the other [49]. Overall rates of treatment success were similar for topical NSAID (57%) and oral NSAID (62%), with no statistically significant difference (relative benefit 0.9; 0.8 to 1.1).

The other nine trials compared one topical preparation with another (see Additional file 5), For only topical piroxicam 0.5% compared with topical indomethacin 1% was there at least three trials (with 716 patients). Piroxicam was significantly more effective than indomethacin, with improvement in 52% on piroxicam and 39% on indomethacin. The relative benefit was 1.3 (1.1 to 1.5) and the NNT for piroxicam compared with indomethacin

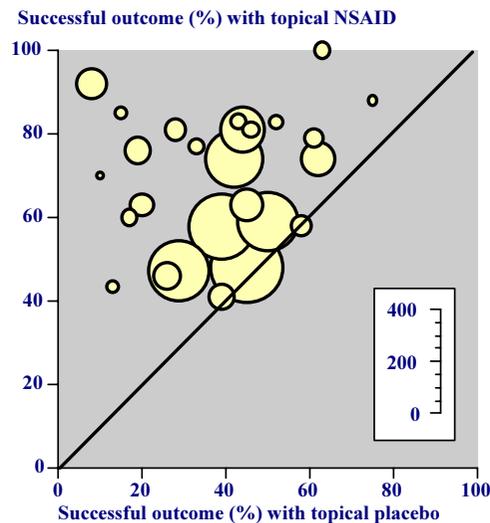


Figure 1

Randomised double-blind studies of topical NSAID compared to topical placebo for one-week outcome of successful treatment. Inset scale shows size of individual trials.

was 8 (5 to 20). Local adverse events were less common with piroxicam (2%) than with indomethacin (10%). The relative risk for an adverse event with piroxicam was 0.2 (0.1 to 0.5) compared with indomethacin, and the number needed to prevent one local adverse event was 14 (9 to 26).

Discussion

The original review [1], and this updated one, concluded that topical analgesics were effective in acute conditions. Despite removing trials of lower quality, and topical agents that are not now regarded as topical NSAIDs, the NNT for all topical NSAIDs compared with placebo for the outcome equivalent to at least half pain relief at seven

days was 3.8 (3.4 to 4.4). The previous review gave an NNT of 3.9 (3.4 to 4.4). Three trials comparing topical with oral NSAID found no difference in efficacy.

What are the limitations of this review that might question this demonstration of efficacy? The included trials spanned several decades, and retrospective examination finds fault with them in several respects. Trials were often small. Small size can lead to the influence of chance effects on treatment and placebo event rates [4]. Different preparations were used, with different application schedules, concentrations of active agent, and formulations. Outcomes in the trials were not consistent, and a hierarchy of outcomes had to be constructed. Some clinical

heterogeneity was therefore inevitable, even when patients in the trials were similar, with similar conditions, when trial designs included both randomisation and double-blinding, and when the duration of trials was appropriate.

We addressed these limitations with pre-planned sensitivity analyses. Using only studies with higher quality and validity scores, or studies with higher rather than lower preference outcomes made no difference (preferred outcomes were patient rated global or pain, lower preference undefined improvement and physician rated global outcomes). Trial size had an important effect, with smaller trials having a lower (better) NNT. The evidence was that topical NSAIDs were effective whatever strategy was used for sensitivity analysis, improving the robustness of the overall result.

Different NSAIDs had different efficacy, with ketoprofen being significantly better than all others in an indirect comparison, while indomethacin was barely distinguished from placebo. The only direct comparison of topical preparations where there was an adequate amount of information to pool (three trials and 716 patients) was for topical piroxicam compared with topical indomethacin. Topical piroxicam was significantly more effective than topical indomethacin, supporting the indirect comparison.

A possible criticism might be that there has been selective publication of trials showing topical NSAIDs to be effective, and suppression of trials where there was no difference between topical NSAID and placebo. Funnel plots do not reliably detect publication bias [13,14], so we did not use them or make any adjustment for possible publication bias [53]. We did approach every company in the world that we could identify as being involved with topical NSAID manufacture or sale for any additional unpublished trials. No more unpublished material was identified than in the original review [1]. When unpublished material is found, it often does not change the relevance of a result [54-56].

It is important to emphasise that both active and placebo treatments were rubbed on, making any effect of rubbing equal in both groups. It's not just the rubbing! The average placebo response in the included trials was 39%, compared with the average response of 65% with topical NSAID. The response with placebo is consistent with that found in painful conditions using a variety of conditions and endpoints [57].

While there may be reservations about the quality and amount of information available for topical NSAIDs in acute conditions, the comparison with NSAIDs in other

conditions is favourable. For instance, in dysmenorrhoeas, a Cochrane review of NSAIDs [58] included 4,066 women, but the trials themselves were small, with an average of about 50 per trial. These 63 randomised double-blind trials investigated 21 different NSAIDs, each at different doses, in studies of varying design, varying outcomes, and varying duration. Two Cochrane reviews of NSAIDs for osteoarthritis in hip and knee [59,60] had only 3,000 patients in 29 trials.

One implication of short duration studies is that they will not capture important long-term safety information. This may be important for ongoing applications of gels, creams or sprays. There is, however, information that indicates that topical NSAIDs do not cause the gastrointestinal harm found with oral NSAIDs [61], nor are they associated with increased renal failure [62].

Clearly there is a body of evidence to support the efficacy of topical NSAIDs in acute painful conditions. The evidence of efficacy remains despite removing smaller studies lacking double blinding that are open to bias, and substituting newer, larger trials of high quality.

Conclusions

Topical NSAIDs were effective and safe in treating acute painful conditions for one week.

Competing interests

RAM & HJM have consulted for various pharmaceutical companies. RAM, HJM & JE have received lecture fees from pharmaceutical companies related to analgesics and other healthcare interventions, including NSAIDs. RAM & HJM have consulted and received lecture fees from pharmaceutical companies related to topical analgesics, including NSAIDs. All authors have received research support from charities, government and industry sources at various times, but no such support was received for this work. No author has any direct stock holding in any pharmaceutical company.

Authors' contributions

LM was involved with planning the study, searching, data extraction, analysis, and preparing a manuscript; RAM with planning, data extraction, analysis and writing the manuscript; JE with searching, data extraction, and writing; SD with data extraction, analysis, and writing; HJM with planning, analysis and writing. All authors read and approved the final manuscript.

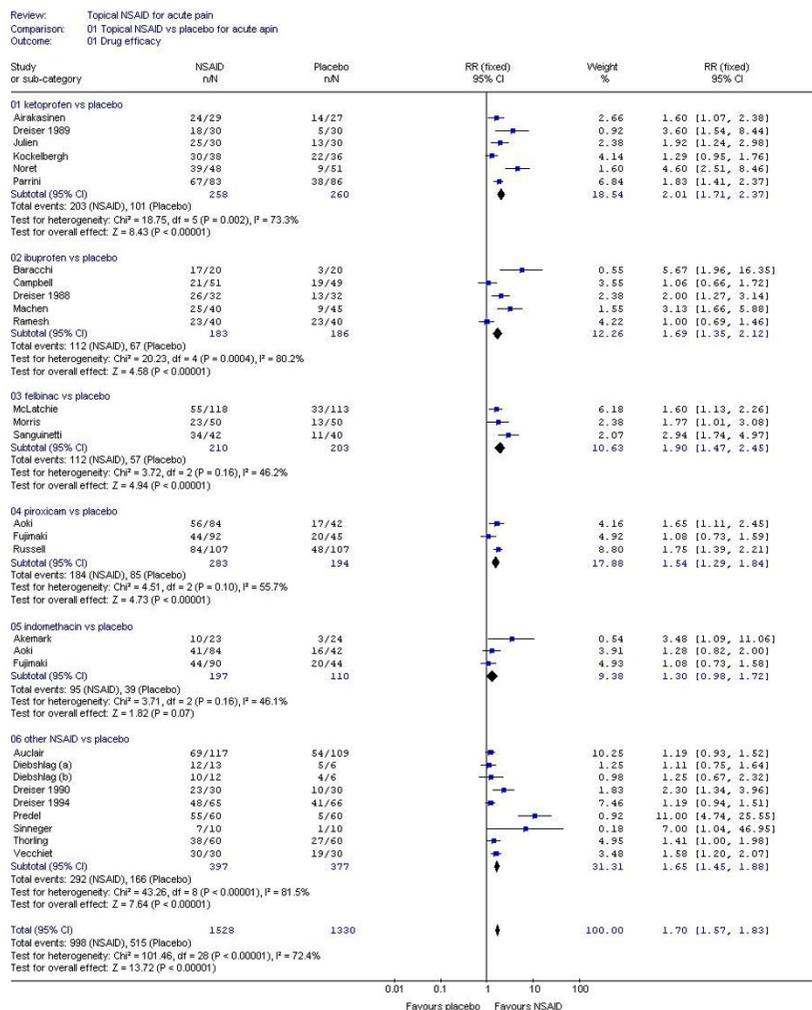


Figure 2
 Analysis of trials of topical NSAIDs in acute painful conditions. This Forrest plot was created using RevMan 4.2. Details of the statistical tests used can be found in the Cochrane Handbook.

Additional material

Additional File 1

Search strategy for RCTs of topical NSAIDs in acute pain

Click here for file

[<http://www.biomedcentral.com/content/supplementary/1471-2296-5-10-S1.doc>]

Additional File 2

Studies excluded from the review

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[<http://www.biomedcentral.com/content/supplementary/1471-2296-5-10-S2.xls>]

Additional File 3

QUOROM flow diagram

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Additional File 4

Outcome details of placebo-controlled trials

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Additional File 5

Outcome details of active-controlled trials

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References

- Moore RA, Tramer MR, Carroll D, Wiffen PJ, McQuay HJ: **Quantitative systematic review of topically applied non-steroidal anti-inflammatory drugs.** *BMJ* 1998, **316**:333-338.
- Begg C, Cho M, Eastwood S, Horton R, Moher D, Olkin I, Pitkin R, Rennie D, Schulz KF, Simel D, Stroup DF: **Improving the quality of reporting of randomized controlled trials. The CONSORT statement.** *JAMA* 1996, **276**:637-639.
- Moher D, Pham B, Jones A, Cook DJ, Jadad AR, Moher M, Tugwell P, Klassen TP: **Does quality of reports of randomised trials affect estimates of intervention efficacy reported in meta-analyses?** *Lancet* 1998, **352**:609-613.
- Moore RA, Gavaghan D, Tramer MR, Collins SL, McQuay HJ: **Size is everything—large amounts of information are needed to overcome random effects in estimating direction and magnitude of treatment effects.** *Pain* 1998, **78**:209-216.
- Li Wan Po A: **PJ Practice Checklist: Topical Analgesics.** *The Pharmaceutical Journal* 1996.
- British National Formulary No 45* London: British Medical Association, Royal Pharmaceutical Society; 2003.
- Martindale: the extra pharmacopoeia* 32nd edition. Edited by: Reynolds JEF. London: Royal Pharmaceutical Society; 1999.
- Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, McQuay HJ: **Assessing the quality of reports of randomized clinical trials: is blinding necessary?** *Control Clin Trials* 1996, **17**:1-12.
- Smith LA, Oldman AD, McQuay HJ, Moore RA: **Teasing apart quality and validity in systematic reviews: an example from acupuncture trials in chronic neck and back pain.** *Pain* 2000, **86**:119-132.
- Cook RJ, Sackett DL: **The number needed to treat: a clinically useful measure of treatment effect.** *BMJ* 1995, **310**:452-454.
- Morris JA, Gardner MJ: **Calculating confidence intervals for relative risk, odds ratios and standardised ratios and rates.** In *Statistics with confidence – confidence intervals and statistical guidelines* Edited by: Gardner MJ, Altman DG. London: British Medical Journal; 1995:50-63.
- L'Abbe KA, Detsky AS, O'Rourke K: **Meta-analysis in clinical research.** *Ann Intern Med* 1987, **107**:224-233.
- Gavaghan DJ, Moore RA, McQuay HJ: **An evaluation of homogeneity tests in meta-analyses in pain using simulations of individual patient data.** *Pain* 2000, **85**:415-424.
- Higgins J, Thompson S, Deeks J, Altman D: **Statistical heterogeneity in systematic reviews of clinical trials: a critical appraisal of guidelines and practice.** *J Health Serv Res Policy* 2002, **7**:51-61.
- Tramer MR, Reynolds DJ, Moore RA, McQuay HJ: **Impact of covert duplicate publication on meta-analysis: a case study.** *BMJ* 1997, **315**:635-640.
- Moher D, Cook DJ, Eastwood S, Olkin I, Rennie D, Stroup DF: **Improving the quality of reports of meta-analyses of randomised controlled trials: the QUOROM statement. Quality of reporting of meta-analyses.** *Lancet* 1999, **354**:1896-1900.
- Predel: **Diclofenac patch for topical treatment of acute impact injuries: a randomised, double blind, placebo controlled, multicentre study.** Supplied by Novartis in press.
- Airaksinen O, Venäläinen J, Pietiläinen T: **Ketoprofen 2.5% gel versus placebo gel in the treatment of acute soft tissue injuries.** *Int J Clin Pharmacol Ther Toxicol* 1993, **31**:561-563.
- Auclair J, Georges M, Grapton X, Gryp L, D'Hooghe M, Meisser RG, Noto R, Schmidtmayer B: **A double-blind controlled multicenter study of percutaneous niflumic acid gel and placebo in the treatment of achilles heel tendinitis.** *Curr Ther Res* 1989, **46**:782-788.
- Baracchi G, Messina Denaro S, Piscini S: **Experience of the topical use of isobutylfenylpropionic acid (Ibuprofen) in traumatic inflammation. A double-blind comparison with placebo.** *Gazz Med Ital* 1982, **141**:691-694.
- Billigman PV: **Therapie von Sprunggelenks-distosionen mit ibuprofen-mikrogele.** *Therapiewoche* 1996, **21**:1187-1192.
- Campbell J, Dunn T: **Evaluation of topical ibuprofen cream in the treatment of acute ankle sprains.** *J Accid Emerg Med* 1994, **11**:178-182.
- Dreiser RL: **Clinical trial of efficacy and tolerability of topical ibuprofen in the treatment of tendinitis.** *Le Journal International De Médecine* 1988, **119**:15-31.
- Dreiser RL: **Clinical trial – Fatsum gel FG-6.** Supplied by Menarini 1989 in press.
- Dreiser RE, Charlot J, Lopez A, Ditisheim A: **Clinical evaluation of niflumic acid gel in the treatment of uncomplicated ankle sprains.** *Curr Med Res Opin* 1990, **12**:93-99.
- Dreiser RL, Roche R, de Sahb R, Thomas F, Leutenegger E: **Flurbiprofen local action transcutaneous (LAT™): Clinical evaluation in the treatment of acute ankle sprains.** *Eur J Rheumatol Inflamm* 1994, **14**:9-13.
- Galer BS, Rowbotham M, Perander J, Devers A, Friedman E: **Topical diclofenac patch relieves minor sports injury pain: results of a multicenter controlled clinical trial.** *J Pain Symptom Manage* 2000, **19**:287-294.
- Julien D: **Clinical trial – Fastum gel FG-8.** Supplied by Menarini 1989 in press.
- Kockelbergh M, Verspeelt P, Caloine R, Dermaux F: **Local anti-inflammatory treatment with a ketoprofen gel: current clinical findings.** *J Belg Med Phys Rehabil* 1985, **8**:205-213.
- Machen J, Whitefield M: **Efficacy of a proprietary ibuprofen gel in soft tissue injuries: a randomised, double blind placebo controlled study.** *Int J Clin Pharmacol* 2002, **56**:102-106.
- McLatchie GR, McDonald M, Lawrence GF, Rogmans D, Lisai P, Hibberd M: **Soft tissue trauma: a randomised controlled trial of the topical application of felbinac, a new NSAID.** *Br J Clin Pract* 1989, **43**:277-280.
- Morris WD, Scott HV, Peters WA, Ketelbey JW: **Felbinac topical gel for acute soft tissue sports injuries.** *N Z J Sports Med* 1991, **19**:45-47.

33. Noret A, Roty V, Allington N, Hauters P, Zuinen C, Poels R: **Ketoprofen gel as topical treatment for sport injuries.** *Acta Ther* 1987, **13**:367-378.
34. Parrini M, Cabitza P, Arrigo A, Vanasia M: **Efficacy and tolerability of ketoprofen lysine salt foam for topical use in the treatment of traumatic pathologies of the locomotor apparatus.** *Clin Ter* 1992, **141**:199-204.
35. Ramesh N, Steuber U: **Dolgit® cream in accident- and sports-related injuries in medical practice. Results of a double blind study.** *Therapiewoche* 1983, **33**:4563-4570.
36. Russell AL: **Piroxicam 0.5% topical gel compared to placebo in the treatment of acute soft tissue injuries: a double-blind study comparing efficacy and safety.** *Clin Invest Med* 1991, **14**:35-43.
37. Sanguinetti C: **Trattamento con BPAA gel dei traumi dei tessuti molli.** *Clin Ter* 1989, **130**:255-258.
38. Sinniger M, Blanchard P: **Controlled clinical trial with Fentiazac cream in sport microtraumatology.** *J Int Med Res* 1981, **9**:300-302.
39. Thorling J, Linden B, Berg R, Sandahl A: **A double blind comparison of naproxen gel and placebo in the treatment of soft tissue injuries.** *Curr Med Res Opin* 1990, **12**:242-248.
40. Vecchiet L, Colozzi A: **Effects of meclofenamic acid in the treatment of lesions deriving from minor traumatology.** *Clin J Pain* 1991, **7(Suppl 1)**:S54-S59.
41. Battista Curioni G, Domenica FD, Daolio P, Spignoli G: **Valutazione dell'efficacia terapeutica di ibudros gel in traumatologia.** *Clin Eur* 1985, **24**:456-460.
42. Governali E, Casalini D: **Ricerca clinica controllata tra ketoprofene gel 5% e ketoprofene crema 1% in pazienti con postumi di lesioni traumatiche.** *Riabilitazione* 1995, **28**:61-69.
43. Gualdi A, Bonollo L, Martini A, Forgione A: **Antinfiammatori non steroidei per uso topico in traumatologia: studio clinico con flunoxaprofene e chetoprofene.** *Riforma Med* 1987, **102**:401-404.
44. Hosie GAC: **The topical NSAID, felbinac, versus oral ibuprofen: a comparison of efficacy in the treatment of acute lower back injury.** *Br J Clin Res* 1993, **4**:5-17.
45. Picchio AA, Volta S, Longoni A: **Studio clinico controllato sull'impiego dell'ibuprofen per uso topico in traumatologia sportiva.** *Med Sport* 1981, **34**:403-406.
46. Sugioka Y: **Multicenter clinical evaluation of piroxicam gel vs. indomethacin gel in the treatment of non-traumatic diseases of tendon or muscle.** *Jap Pharmacol Ther* 1984, **12**:139-153.
47. Tonutti A: **The use of ketoprofen gel 5% (orudis gel) in traumatology: controlled double-blind study vs etofenamate.** *Ort Traum Oggi* 1994, **14**:119-125.
48. Whitefield M, O'Kane CJA, Anderson S: **Comparative efficacy of a proprietary topical ibuprofen gel and oral ibuprofen in acute soft tissue injuries: a randomised, double blind study.** *J Clin Pharm Ther* 2002, **27**:409-417.
49. Åkermark C, Forsskåhl B: **Topical indomethacin in overuse injuries in athletes. A randomized double blind study comparing Elmetacin® with oral indomethacin and placebo.** *Int J Sports Med* 1990, **11**:393-396.
50. Aoki T, et al.: **Comparative study of piroxicam gel with indomethacin gel and piroxicam placebo gel in the treatment of pain from orthopedic trauma.** *Jap Pharmacol Ther* 1984, **12**:101-117.
51. Diebschlag W, Nocker W, Bullingham R: **A double-blind study of the efficacy of topical ketorolac tromethamine gel in the treatment of ankle sprain, in comparison to placebo and etofenamate.** *J Clin Pharmacol* 1990, **30**:82-89.
52. Fujimaki E, et al.: **Clinical evaluation of piroxicam gel versus indomethacin gel and placebo in the treatment of muscle pain: a double-blind, multicenter study.** *Jap Pharmacol Ther* 1985, **12**:119-137.
53. Terrin N, Schmid CH, Lau J, Olkin I: **Adjusting for publication bias in the presence of heterogeneity.** *Stat Med* 2003, **22**:2113-2126.
54. MacLean CH, Morton SC, Ofman JJ, Roth EA, Shekelle PG: **How useful are unpublished data from the Food and Drug Administration in meta-analysis?** *J Clin Epidemiol* 2003, **56**:44-51.
55. Egger M, Juni P, Bartlett C, Holenstein F, Sterne J: **How important are comprehensive literature searches and the assessment of trial quality in systematic reviews. Empirical study.** *Health Technol Assess* 2003, **7**:1-76.
56. Burdett S, Stewart LA, Tierney JF: **Publication bias and meta-analyses: a practical example.** *Int J Technol Assess Health Care* 2003, **19**:129-134.
57. Kalso E, Moore RA: **Five easy pieces on evidence-based medicine (2).** *Eur J Pain* 2000, **4**:321-324.
58. Marjoribanks J, Proctor M, Farquhar C: **Nonsteroidal anti-inflammatory drugs for primary dysmenorrhoea.** *Cochrane Database Syst Rev* 2003, **4**:CD001751.
59. Towheed T, Shea B, Wells G, Hochberg M: **Analgesia and non-aspirin, non-steroidal anti-inflammatory drugs for osteoarthritis of the hip.** *Cochrane Database Syst Rev* 2000, **2**:CD000517.
60. Watson MC, Brookes ST, Kirwan JR, Faulkner A: **Non-aspirin, non-steroidal anti-inflammatory drugs (NSAIDs) for osteoarthritis of the knee.** *Cochrane Database Syst Rev* 2000, **2**:CD000142.
61. Evans JM, McMahon AD, McGilchrist MM, White G, Murray FE, McDevitt DG, MacDonald TM: **Topical non-steroidal anti-inflammatory drugs and admission to hospital for upper gastrointestinal bleeding and perforation: a record linkage case-control study.** *BMJ* 1995, **311**:22-26.
62. Evans JM, McGregor E, McMahon AD, McGilchrist MM, Jones MC, White G, McDevitt DG, MacDonald TM: **Non-steroidal anti-inflammatory drugs and hospitalization for acute renal failure.** *QJM* 1995, **88**:551-557.

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