



Minimally invasive versus open surgery for acute Achilles tendon ruptures a systematic review and meta-analysis

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The minimally invasive surgery (MIS) approach has been popularised as an alternative to the standard open approach in acute Achilles tendon repair. Advocates of MIS suggest earlier functional recovery, due to reduced trauma to adjacent soft tissues. Critics, however, argue that due to inadequate surgical exposure, complications of such surgery are higher compared to an open technique.

A systematic review and meta-analysis of randomised, prospective studies was conducted to compare MIS and open surgery in acute Achilles tendon ruptures.

Thirteen studies were included in the meta-analysis with a total of 854 patients. Although re-rupture rates were not significantly different between the groups ($P = 0.43$), there were significantly more complications in the open surgery group ($P = <.00001$).

MIS in acute Achilles tendon ruptures result in similar re-rupture rates, sural nerve injury rates and return to sport time in comparison with open surgical method, but with significantly less post-operative complications.

Keywords : Acute Achilles tendon injury ; Tendon repair

INTRODUCTION

Treatment of the acute Achilles tendon rupture remains controversial. Operative treatment is quoted to have a lower rate of re-rupture in comparison with

conservative treatment. Significant complications, however, have been reported following operative treatment, such as : wound healing problems, nerve injuries, scarring around the tendon and infection (3,9,22). The minimally invasive (MIS) approach has been popularised as an alternative to the standard open approach in acute Achilles tendon ruptures. Advocates of this technique suggest fewer wound healing problems and earlier functional recovery, due to less injury to the surrounding tissues. However, critics argue that due to reduced exposure, risk and complications of such surgery are higher in comparison to the open technique.

In this study, the authors propose that there is a lower incidence of complication in MIS compared to open surgery for the surgical management of acute Achilles tendon ruptures. To test this hypothesis a systematic review and meta-analysis

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*No benefits or funds were received in support of this study.
The authors report no conflict of interests.*

was conducted, using existing prospective and randomised controlled trials. In our study, as secondary outcome measures, we also look at the re-rupture rates, sural nerve injuries and return to sports rates in above two groups of patients.

MATERIALS & METHODS

A systematic review and meta-analysis was conducted according to guidelines described in the Cochrane handbook for systematic reviews of interventions and PRISMA statement (7, 15).

Only randomised controlled trials (RCTs), and prospective cohort studies are included in this study. Participants were all adult patients who underwent MIS or open surgery for acute rupture of the Achilles tendon. Exclusion criteria were retrospective studies, animal studies, studies where the following outcomes are not evaluated and where minimally invasive techniques are not utilised. Outcome measures used were : post-operative complication rates, incidence of sural nerve injury, incidence of re-rupture and return to sports.

The following databases were searched in March 2015 to establish whether there has been any previous systematic reviews or meta-analyses comparing MIS and open surgery in acute Achilles tendon ruptures : Cochrane Database of Systematic Reviews (www.cochrane.org), Database of Abstracts of Reviews of Effects (www.crd.york.ac.uk/CRDWeb), and Medline (1950 to March 2015).

The following exploded MeSH terms were used for the literature search : “Achilles tendon”, “minimally”, and “percutaneous”. A MEDLINE search was then refined to find prospective studies and RCTs. The search was extended to EMBASE database for studies published in any language from 1966 to March 2015. The bibliographies of retrieved trials were examined for additional articles. The following websites were searched to identify unpublished and ongoing studies : Current Controlled Trials (controlled-trials.com) ; Center Watch (www.centerwatch.com) ; Trials Central www.trialscentral.org ; System for Information on Grey Literature in Europe (www.opengrey.eu) ; The UK National Research Register (www.nihr.ac.uk).

The search strategy was applied independently by two of the authors and all relevant study abstracts were hand searched. After which potentially suitable studies were reviewed in full paper format by each of the authors independently. Disagreement was discussed and resolved with the other authors.

The review authors used a modification of the generic evaluation tool used by the Cochrane Bone, Joint and Muscle Trauma Group (*Appendix 1*) (6). This includes 12 points where each point is scored 2, 1 or 0 (maximum score 24) depending on whether the question was fully, partly or not answered at all for each study. Quality assessment scoring (QAS) was performed by two of the authors independently, and any disagreements were resolved by discussion and mutual agreement. Although the total quality assessment score was calculated for each study, it was not used to weight the studies in the meta-analysis.

Meta-analysis, performed by Review Manager [Computer program] (Version 5.3. Copenhagen : The Nordic Cochrane Centre, The Cochrane Collaboration, 2012), was used to combine the relevant estimates of the effect of interest from the selected studies to provide an overall estimate of the effect. In one study (21), there were two different MIS approaches (limited incision MIS and percutaneous technique) were compared with the open technique. On this occasion the study was analysed twice.

Dichotomous data for each arm in a particular study were expressed as proportions or risks and the treatment effect as risk ratios. For dichotomous data, the Mantel-Haenszel method was used to combine the estimates (13). Statistical heterogeneity was assessed using the value of I^2 and the result of the chi-squared test. A P value of less than 0.1 and an I^2 value greater than 50% were considered suggestive of statistical heterogeneity, prompting random effects modelling estimate. Otherwise, a fixed-effect approach was used. On the other hand, a non-significant chi-squared test result only suggested that there is no evidence of heterogeneity. It did not imply that there was necessarily homogeneity as there may have been insufficient power to be able to detect heterogeneity.

Table I. — Characteristics of the included studies

	MIS					Open surgery						
	n	Technique	M	F	Age Mean (range)	FU months Mean (range)	n	Technique	M	F	Age Mean (range)	FU months Mean (range)
Aktas	20	Achillon	18	2	39.2 (29-55)	22.5 (range NS)	20	Krakow end to end	17	3	40.6 (32-65)	22.2 (range NS)
Bhattacharyya	25	Achillon	NS	NS	NS	Minimum 12 (range NS)	34	End-to-end	NS	NS	NS	Minimum 12 (range NS)
Cretnik	132	Modified Ma & Griffith (percutaneous) With USS guidance	124	8	40.2 (20-76)	24 (range NS)	105	Kessler end-to-end	99	6	37.6 (26-76)	24 (range NS)
Gigante	20	Percutaneous repair with implantation of Tenolig	NS	NS	NS	24 (range NS)	20	Kessler end-to-end	NS	NS	NS	24 (range NS)
Kolodziej	24	Achillon	23	1	44.8 (30-60)	24 (range NS)	27	Krakow end to end	26	1	47.1 (26-74)	24 (range NS)
Lim	33	Modified Ma & Griffith (percutaneous)	19	14	40.1	6 (range NS)	33	Modified Kessler end-to-end	20	13	36.9	6 (range NS)
Majewski	30	(percutaneous)	NS	NS	NS	28 (range NS)	29	NS	NS	NS	NS	27 (range NS)
Ng	25	Double-ended needle repair (percutaneous)	17	8	34 (19-68)	65.5 (34-90)	43	NS	30	13	36 (17-74)	65.5 (34-90)
Paton	7	Mini open-Kessler stitch	7	0	28.4 (22-35)	12 (range NS)	18	Modified Kessler end-to-end	18	0	30.6 (20-45)	12 (range NS)
Schroeder	15	NS	NS	NS	NS	NS	13	NS	NS	NS	NS	NS
Valencia	28	Achillon	NS	NS	35	4 (range NS)	28	Lynn's technique	NS	NS	35	4 (range NS)
Wagnon	22	Webb-Bannister (percutaneous)	NS	NS	43	40 (range NS)	35	posteromedial incision without reinforced suturing	NS	NS	43	40 (range NS)
Wang	23	Ma & Griffith (percutaneous)	16	7	27.3 (19-45)	14.9 (range NS)	23	Kessler end-to-end	15	8	28.9 (21-48)	14.9 (range NS)

n= number of cases, M= male, F= female, NS= Not specified, FU= follow up
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RESULTS

Searches for existent meta-analyses showed one such meta-analysis in the literature comparing MIS versus open surgery in acute Achilles tendon ruptures (14). Nine hundred and seventy-two primary studies were identified. After duplicates were removed, 937 papers were excluded based on the inclusion/exclusion criteria, leaving 21 potentially relevant studies for detailed evaluation. This was further reduced to 13 studies for inclusion in the meta-analysis, *Appendix 2* shows the study selection flow according to PRISMA guidelines.

Reasons for exclusion were included irrelevant studies and studies with retrospective nature. *Appendix 3* and Table I show the quality assessment scores and the included studies with their characteristics (21,1,2,4,5,10,11,12,16,17,18,19,20).

Five of the studies were prospective cohort (38%), whereas the remaining eight were RCTs (62%). MIS was utilised in 426 patients whilst 428 patients underwent an open surgery. The mean age of patients was 38 years (range 19-76) for the MIS and 37 years (range 17-76) for the open group.

Complications

All 13 studies combined in this meta-analysis yielded 426 patients in the MIS group, and 451 patients in the open surgery group. Incidence of

post-operative complication was 32 and 109 for these two groups respectively (21,1,2,4,5,10,11,12,16,17,18,19,20).

The chi-square test for heterogeneity was 17.84 (df = 13, $P = 0.16$), indicating no statistical heterogeneity on all included studies and a fixed-effects analysis model was used. Odds ratio between MIS and open group was 0.27 (CI 95%, 0.18 to 0.40, $P < 0.00001$) (Table II).

Reported complications in all studies were ; deep infection requiring debridement, superficial infection, insertional tendinopathy, ankle stiffness, haematoma formation, wound dehiscence, delayed wound healing, deep vein thrombosis, partial and complete re-ruptures, extreme lengthening of the tendon, chronic fistula, skin necrosis, scar tethering, altered sensation, thrombophlebitis, keloid formation and pain.

Sural nerve injury

Seven studies reported on this outcome, from a total of 275 MIS patients and 283 open surgery patients (1,4,5,10,11,16,20).

There were 7 sural nerve injuries in the MIS group and 4 in the open group. The chi-square test for heterogeneity was .56 (df = 2, $P = 0.75$), indicating no statistical heterogeneity on all included studies and a fixed-effects analysis model was used. Odds

Table II. — Forest plot analysis of the complications outcome

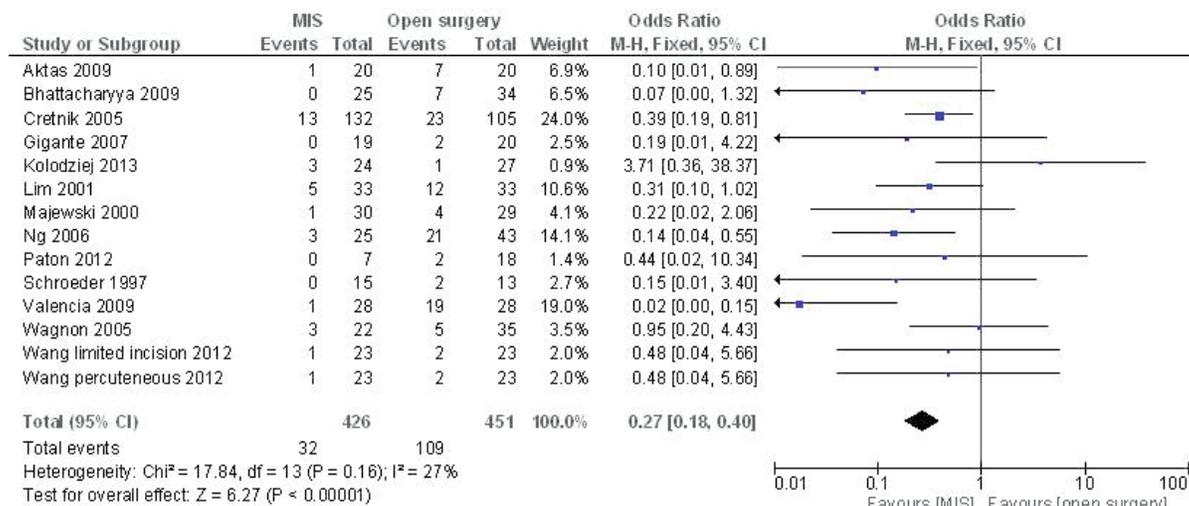


Table III. — Forest plot analysis of sural nerve injuries outcome

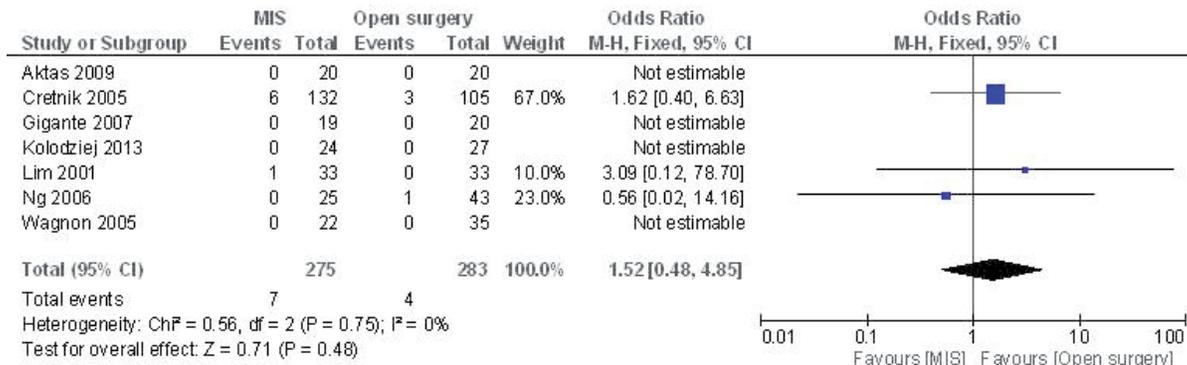
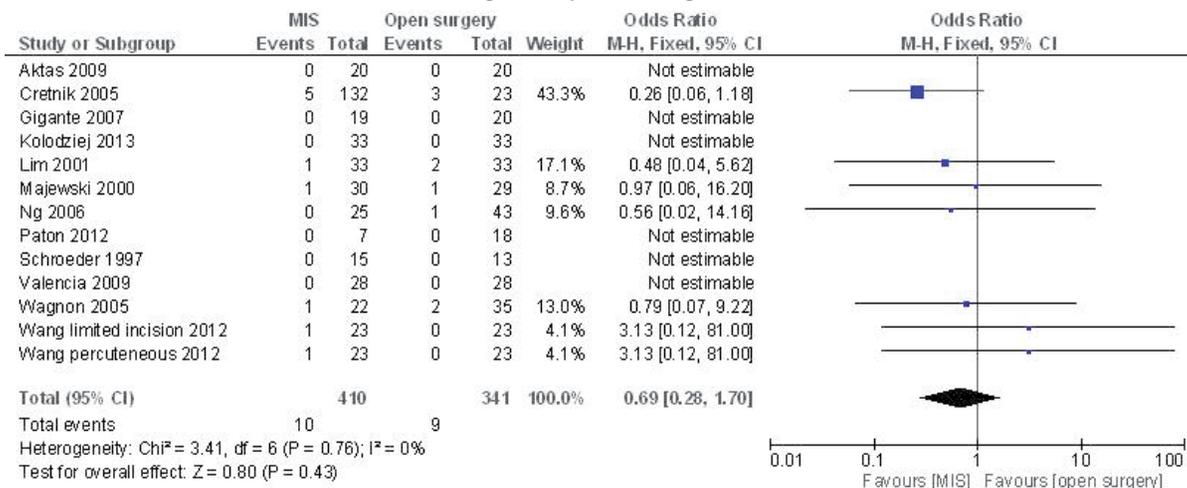


Table IV. — Forest plot analysis of re-rupture rates outcome



ratio between MIS and open group was 1.52 (CI 95%, 0.48 to 4.85, $P = 0.48$) (Table III).

Re-rupture rates

Twelve studies reported on re-ruptures from a total of 410 patients in the MIS group and 341 patients in the open group (21,1,4,5,10,11,12,16,17,18,19,20).

There were 10 events in the first and 9 events in the second group. The chi-square test for heterogeneity was 3.41 (df = 6, $P = 0.76$), indicating no statistical heterogeneity on all included studies and a fixed-effects analysis model was used. Odds ratio

between MIS and open group was .69 (CI 95%, 0.28 to 1.70, $P = 0.43$) (Table IV).

Return to sports

Five studies reported on return to sports from a total of 224 patients in the MIS group and 198 patients in the open surgery group (1, 4, 10, 11, 18).

184 patients returned to full sporting activities from the MIS group and 147 patients from the open surgery group. The chi-square test for heterogeneity was 1.38 (df = 4, $P = 0.85$), indicating no statistical heterogeneity and a fixed-effects analysis model was used. Odds ratio between MIS and open group

• Table V. —Forest plot analysis of return to sports outcome

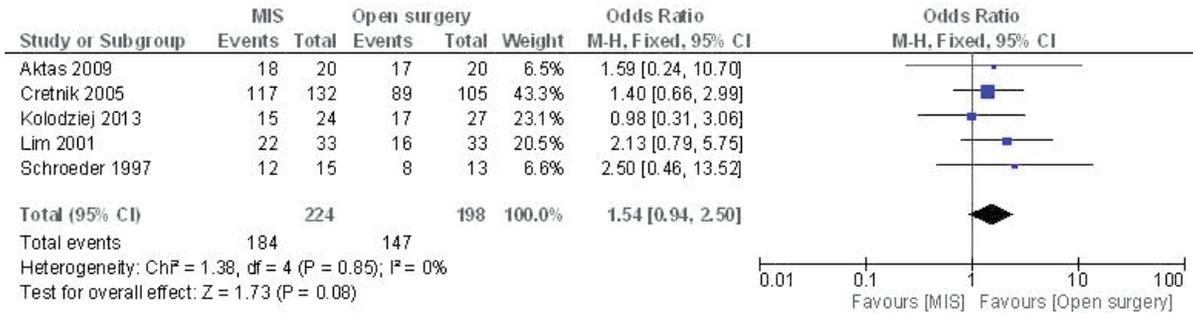
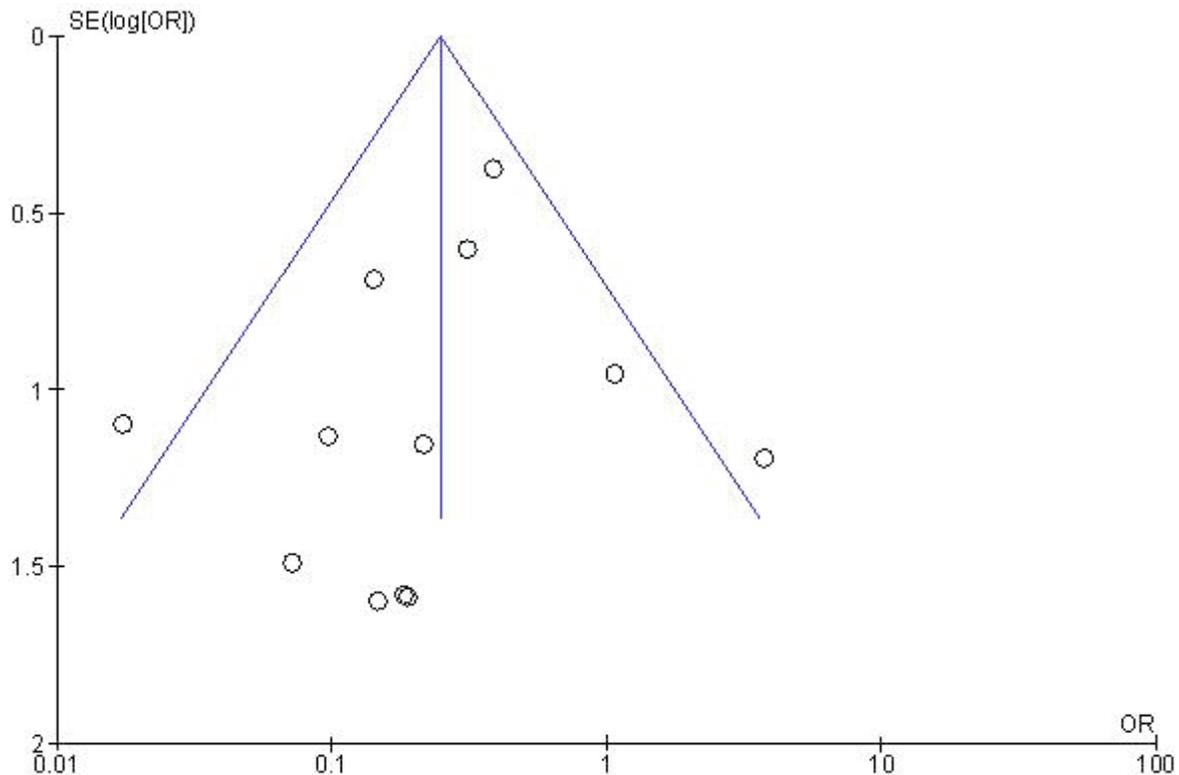


Table VI. — Funnel plot analysis for publication bias



was 1.54 (CI 95%, 0.94 to 2.50, $P = 0.08$) (Table V).

Publication bias

Complications outcome was the most commonly used outcomes by the studies. Therefore a funnel plot was produced on this and showed roughly sym-

metrical distribution indicating minimal evidence of a publication bias (Table VI).

DISCUSSION

Our study showed that overall complication rates were significantly higher in the open surgery group, compared to the study group. Therefore, the

initial hypothesis appears to have been confirmed. MIS techniques have been suggested to yield an increased incidence of sural nerve complications, due to limited or lack of proper visualisation of the structures at the operation site (1, 8). However, this has not been clearly proved in our review. There were a similar number of sural nerve injuries in both groups and a statistically significant difference was not demonstrated. It is also perhaps worth noting that there were fewer patients in the open group. Regarding our secondary outcome measures, there were no statistically significant differences looking at re-rupture rates and return to sporting activities.

A previous meta-analysis on this subject by McMahan et al in 2010 (14), analysing 6 studies on 136 MIS and 141 cases of conventional open repair, showed that there were similar re-rupture rates and sural nerve injuries between the groups. Our meta-analysis supports their results. They have also reported in their study on some complications individually, such as deep infection, tissue adhesion, and deep vein thrombosis (DVT). In that study, none of the above mentioned complications yielded a statistically significant result between the two groups.

In this meta-analysis, however, overall complication rates have been shown to be higher in the open surgery group. In our opinion, the previous study may have had lower statistical power due to a smaller case cohort. For example, the analysis of DVT incidence was based on only 35 patients in the MIS group, and 33 patients in the open surgery group, reported over two studies. Similarly, with regard to tissue adhesion, there were 61 patients in each group which was reported in, again, only two studies. We have reported the total number of complications in 13 studies looking at over 800 patients.

Limitations of our study are variations between the studies analysed such as : difference in sample size, patient demographics (such as race, age, gender and BMI), different inclusion and exclusion criteria for each study, and the differences in post operative management protocols between centres. It is also worth mentioning that, our study analyses some prospective cohort studies as well as RCTs. This is due to there being only a few RCTs in the

literature. Furthermore, the studies included in this meta-analysis are methodologically not found to be robust. Therefore, there is a need for well designed future blinded randomised controlled studies to investigate the long term success of MIS technique. Due to our extensive literature search, this meta-analysis is the largest on this subject, using up to date evidence obtained from reports in four different languages.

Acknowledgment

Authors gratefully acknowledge the assistance of the librarians of York Teaching Hospitals NHS Foundation Trust.

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Appendix 1 : Quality assessment items and possible scores

- A. Was the assigned treatment adequately concealed prior to allocation?
 - 2 = method did not allow disclosure of assignment
 - 1 = small but possible chance of disclosure of assignment or unclear
 - 0 = quasi-randomised or open list/tables
- B. Were the outcomes of participants who withdrew described and included in the analysis (intention to treat)?
 - 2 = withdrawals well described and accounted for in analysis
 - 1 = withdrawals described and analysis not possible
 - 0 = no mention, inadequate mention, or obvious differences and no adjustment
- C. Were the outcome assessors blinded to treatment status?
 - 2 = effective action taken to blind assessors
 - 1 = small or moderate chance of unblinding of assessors
 - 0 = not mentioned or not possible
- D. Were the treatment and control group comparable at entry? (Likely confounders may be age, partial or total rupture, activity level, acute or chronic injury)
 - 2 = good comparability of groups, or confounding adjusted for in analysis
 - 1 = confounding small ; mentioned but not adjusted for
 - 0 = large potential for confounding, or not discussed
- E. Were the participants blind to assignment status after allocation?
 - 2 = effective action taken to blind participants
 - 1 = small or moderate chance of unblinding of participants
 - 0 = not possible, or not mentioned (unless double-blind), or possible but not done

- F. Were the treatment providers blind to assignment status?
2 = effective action taken to blind treatment providers
1 = small or moderate chance of unblinding of treatment providers
0 = not possible, or not mentioned (unless double-blind), or possible but not done
- G. Were care programmes, other than the trial options, identical?
2 = care programmes clearly identical
1 = clear but trivial differences
0 = not mentioned or clear and important differences in care programmes
- H. Were the inclusion and exclusion criteria clearly defined?
2 = clearly defined
1 = inadequately defined
0 = not defined
- I. Were the interventions clearly defined?
2 = clearly defined interventions are applied with a standardised protocol
1 = clearly defined interventions are applied but the application protocol is not standardised
0 = intervention and/or application protocol are poorly or not defined
- J. Were the outcome measures used clearly defined? (by outcome)
2 = clearly defined
1 = inadequately defined
0 = not defined
- K. Were diagnostic tests used in outcome assessment clinically useful? (by outcome)
2 = optimal
1 = adequate
0 = not defined, not adequate
- L. Was the surveillance active, and of clinically appropriate duration?
2 = active surveillance and appropriate duration
1 = active surveillance, but inadequate duration
0 = surveillance not active or not defined