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ORIGINAL ARTICLE

Comparing Outcomes of Displaced Distal Radius Fracture Treated by Volar Plate

Mohamed Abd Allah El-Soufy[1], Amr Mohamed Eladawy[1], Tarek Abd ELSamad EL-Hewala[1], Asuikar O Buzaid Faraj[2*]

[1]Orthopedic Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt
[2]Orthopedic department, Faculty of medicine, Benghazi University, Libya

Corresponding Author:
Asuikar O Buzaid Faraj

Email:
buzaidmalak2@yahoo.com

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ABSTRACT

Background: In clinical practice, dorsally displaced distal radius fracture (DDDRF) is a common injury. K-wires and open reduction with a volar locking plate (VLP) are the two most common surgical procedures used to fix DDDRF. However, at this time there, is no solid evidence to advise the adoption of one procedure over another. Therefore, the aim of our meta-analysis is to compare the functional outcomes of DDDRE treated by VLP versus k wire and to compare wrist motion, radiographic outcomes, and complications of volar plate versus k wire in patients with displaced distal radius fractures.

Method: This meta-analysis reviewed 7 different studies to identify the best option for treatment of distal radial fracture. We looked for clinical studies which compared K-wire fixation of the distal radius to volar locked plate fixation for the treatment of radius shaft fractures in adults. After analyzing the included studies, we pooled the available data about operative time and post-operative data like union time (UT), angulation, complex regional pain trauma (CRPT), disability of the arm shoulder and hand (DASH), patient rated wrist evaluation (PRWE), implant failure, infection, and other surgical wound complications.

Results: Open reduction and internal fixation (ORIF) with a VLP and closed reduction with percutaneous Kirschner wire fixation provide comparable excellent clinical and radiographic results in patients with distal radial fractures. ORIF with VLP fixation provided less DASH scores than closed reduction with percutaneous Kirschner wire fixation.

Conclusions: K wiring remains a simple and inexpensive option for simple fracture patterns.

Key words: DDDRF, volar locking plate, K-wire, Meta-analysis.

INTRODUCTION

The bulk of orthopedic fractures is radial distal fractures which account for one-sixth to one-fourth of all fractures treated in clinical emergency rooms [1]. Postmenopausal women are more likely to suffer from these fractures. Women have a 15% lifetime risk of sustaining a distal radius fracture whereas men have a 2% risk [2].

The most common form of fracture is dorsally displaced distal radius fracture. The prevalence of this fracture type is expected to rise in the coming years. Many of these fractures were previously treated non-operatively. This leads to high frequency of malunion, along with nonoperative care, result in poor clinical outcomes including pain and impairment. Internal fixation method

improvements have increased the reliance of DDDRF management on operational procedures [3].

Closed reduction and cast immobilization, percutaneous K-wire fixation, fixation with volar or dorsal plates (locking or non-locking), bridge plating, use of an external fixator, or a combination of these treatments are all alternatives for patients with distal radius fractures. Although the optimum option is influenced by the fracture's features (open/closed, non-displaced/displaced, extra-/intra-articular), there is a little high-quality information help guide this decision-making. For example, the American Academy of Orthopedic Surgeons (AAOS) produced clinical practice guidelines for distal radius fracture that included 29 suggestions. However, none of these recommendations received a "strong" rating due to the inadequate quality of the evidence [4].

For patients with unstable extra-articular or simple intra-articular distal radius fractures, percutaneous pinning with K-wires was accepted [5]. Biomechanically, the K-wires are not stable enough to stop the radial shortening which has been linked to poor postoperative functional outcomes [6].

It has been becoming more common to use a volar locking plate instead of K-wires for open reduction and internal fixation because it is more stable and allows early hand and wrist movement [7]. So, the aim of our meta-analysis was to compare the radiographic and functional outcomes of displaced distal radius fracture treated by volar plate versus K-wire and to compare wrist motion, radiographic outcomes, and complications of volar plate versus K-wire in patients with displaced distal radius fractures.

METHODS

We conducted this meta-analysis study in the orthopedics surgery department, faculty of medicine, Zagazig university. To find relevant literatures published between 2011 and 2021, a computerized search was conducted in the PubMed, Medline, Elsevier, Scopus, Google Scholar, and Cochrane Library databases. A search including the single keyword or in combination: “fracture distal radius”, “adult”, “K-wire fixation”, “VLP”, “volar locked plate”, and “ORIF”. We searched for the clinical studies that compare K-wire fixation of distal radius with volar locked plate for treatment of distal radius fracture in adult. The study protocol was registered to institutional review board (IRB) in Zagazig University, March 2021. This Work was performed according to the code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria applied for identification relevant studies were studies comparing K-wire fixation with VLP for treatment distal radius fracture, studies in English language, studies including age between 18-65 years, studies including closed unilateral distal radius. We excluded studies containing pathological fracture, open fracture, studies investigating only plate fixation or K-wire, case report, and review literature.

Following the removal of duplicates, the two researchers (T.E and A.P) separately assessed the titles and abstracts. Then, based on the inclusion and exclusion criteria for this study, they investigated the complete text. Clinical outcomes data was operative time and post-operative data like union time (UT), angulation, complex regional pain trauma (CRPT), disability of the arm shoulder and hand (DASH), patient rated wrist evaluation (PRWE), implant failure, infection, and other surgical wound complications. The assessment was done using Cochrane Handbook Tool 5.1.0; the researchers were in charge to assess the methodological quality for each included study.

Statistical Analysis:

Data was entered and organized in Microsoft Excel 2010 before being exported to sophisticated meta-analysis software version 3. Multiple studies were aggregated for analysis, yielding an adjusted accumulative outcome. To test for the mean difference, the Z score approach is utilized. It is approximately distributed as a chi-square with k-1 degrees of freedom under Cochran's Q and I2 tests for heterogeneity, test heterogeneity, and homogeneity of study outcomes and conclusions under null.

RESULTS

The search strategy yielded 156 relevant articles. Eighty seven articles were excluded based on their title and abstract. Fifty two articles were retrieved (Duplicated) from which 10 articles were also excluded after full text review based on inclusion criteria, exclusion criteria and eligibility. Process is shown in detail in flow chart (Fig.1). At the end, a total of 7 studies (1131 participants) ultimately met the inclusion criteria. All the included studies were comparing fracture distal radius in adults treated with k wire versus those treated with volar plate fixation.

The sociodemographic distribution was as follows: the mean age of all those surveyed was 52.89±14.88, and females outnumbered males by an average of 75.73 percent to 24.27 percent (Table 1).

DASH was significantly higher among cases managed by K-wire in all studies except Costa et al. 2019 [8] and at pooled analysis was also significantly higher among K wire. The existence of homogeneity among research was established. After quantifying these components, no bias accounted for variations in results between studies which were not due to chance. We discovered no substantial heterogeneity and found agreement between the studies (Table 2).

In pooled analysis, PRWE was not significantly different between groups. The existence of homogeneity among research was established. After quantifying these components, no bias accounted for variations in results between studies which were not due to chance. We discovered no substantial heterogeneity and found agreement between the studies (Table 3).

In pooled analysis, duration of surgery was significantly longer in VLP. Homogeneity among studies was founded. No bias accounted for differences in results among studies, which were not due to chance, after quantification of all factors. We found agreement between studied with no significant heterogeneity (Table 4).

Regard pooled analysis, infection was distributed with no significant difference between the two techniques with pooled OR 0.69 (0.3-1.61). The existence of homogeneity among research was established. After quantifying these components, no bias accounted for variations in results between studies which were not due to chance. We discovered no substantial heterogeneity and found agreement between the studies (Table 5).

There was no statistically significant difference between the two approaches in pooled analysis of infection distribution with pooled OR 1.32. (0.7-6.32). The existence of research homogeneity was established. Following quantification of these elements, no bias explained for differences in outcomes between studies which were not due to chance. We discovered no significant heterogeneity and discovered agreement between the studies (Table 6).

Regard pooled analysis, complex regional pain trauma was distributed with no significant difference between two techniques with pooled OR 0.58 (0.11-2.9). The existence of homogeneity among research was established. After quantifying these components, no bias accounted for variations in results between studies which were not due to chance. We discovered no substantial heterogeneity and found agreement between the studies (Table S1).

Regard pooled analysis of the cases with carpal tunnel syndrome (CTS) postoperatively, there was no significant difference between two the techniques with pooled OR 0.86 (0.41-2.13**)**. The existence of homogeneity among research was established. After quantifying these components, no bias accounted for variations in results between studies which were not due to chance. We discovered no substantial heterogeneity and found agreement between the studies (Table S2).

Table 1: Distribution of demographic data among studied studies

Study	N	AGE	SEX	
			Male	Female
Hull et al. [9]	71	58.55±4.96	22.5%	77.5%
Campochiaro et al. [10]	77	43.85±12.36	19.4%	80.6%
Goehre et al. [11]	40	65.23 ± 13.56	NA	NA
Brennan et al. [12]	318	44.36±11.58	35.2%	64.8%
Żyluk et al. [13]	102	60.25 ± 15.55	22.5%	77.5%
Costa et al. [8]	461	NA	16.2%	83.8%
Marandi and Chandan, [14]	62	48.36 ± 15.58	35.4%	64.6%
Pooled		52.89 ± 14.88	24.27%	75.73%

Table 2: DASH & PRWE distribution between Plate and K Wire among all studies

Study	Plate		K wire		Z	P	
	N	mean±SD	N	mean±SD			
DASH							
Hull et al. [9]	36	19.5±9.59	35	25.2±10.85	2.55	0.01*	
Campochiaro et al. [10]	38	8.52±2.22	35	13.0±4.11	5.45	0.00**	
Goehre et al. [11]	21	NA	19	NA	----	----	
Brennan et al. [12]	151	12.07±3.58	167	12.66±4.01	1.42	0.152	
Żyluk et al. [13]	30	12.0±5.85	72	14.0±6.98	0.99	0.321	
Costa et al. [8]	231	20.5±7.6	230	19.6±6.36	1.232	0.21	
Marandi and Chandan, [14]	31	6.03±4.52	31	7.0±5.23	0.852	0.421	
Pooled		13.08±6.55		15.59±7.96	2.39	0.019*	

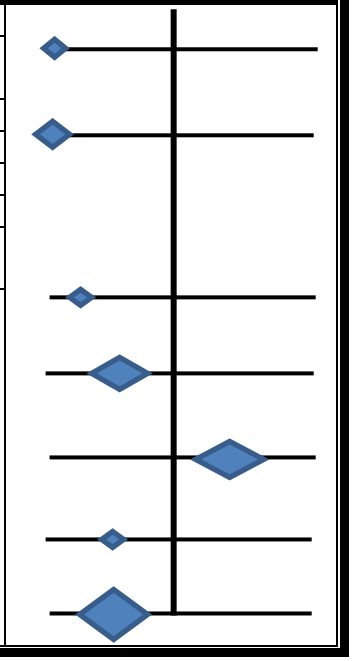

Table 3: DASH distribution between Plate and K Wire among all studies

Study	Plate		K wire		Z	P	
	N	mean±SD	N	mean±SD			
Hull et al. [9]	36	24.6±12.9	35	23.8±11.36	0.29	0.77	
Campochiaro et al. [10]	38	NA	35	NA	----	----	
Goehre et al. [11]	21	NA	19	NA	----	----	
Brennan et al. [12]	151	16.3±5.36	167	17.9.±6.69	1.98	0.045*	
Żyluk et al. [13]	30	12.0±6.98	72	12.0±7.6	0.10	0.99	
Costa et al. [8]	231	8.41±4.36	230	7.21±3.69	2.41	0.02*	
Marandi and Chandan, [14]	31	NA	31	NA	----	----	
Pooled		14.36±7.99		13.98±6.36	0.48	0.62	

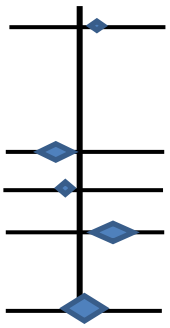

Table 4: Duration of surgery distribution between Plate and K Wire among all studies

Study	Plate		K wire		Z	P	
	N	mean±SD	N	mean±SD			
Hull et al. [9]	36	NA	35	NA	----	----	
Campochiaro et al. [10]	38	NA	35	NA	----	----	
Goehre et al. [11]	21	75.3±26.3	19	25.36±8.36	8.256	0.00**	
Brennan et al. [12]	151	NA	167	NA	----	----	
Żyluk et al. [13]	30	NA	72	NA	----	----	
Costa et al. [8]	231	NA	230	NA	----	----	
Marandi and Chandan, [14]	31	51.6±15.63	31	24.36±7.63	6.854	0.00**	
Pooled		64.63±12.36		24.89±8.58	5.48	0.00**	

Table 5: Infection distribution between groups

Study	Plate		K wire		OR (CI 95%	Z	P	
	N	N %	N	N %				
Hull et al. [9]	36	2 5.5%	35	6 17.4%	0.28 (0.05-1.5)	1.59	0.12	
Campochiaro et al. [10]	38	3 7.8%	35	1 2.8%	----	------	--------	
Goehre et al. [11]	21	NA	19	NA	2.9 (0.29-29.3)	0.92	0.352	
Brennan et al. [12]	151	4 2.6%	167	7 4.1%	0.62 (0.17-2.1)	1.32	0.221	
Żyluk et al. [13]	30	1 3.3%	72	3 4.1%	0.79 (0.07-7.9)	0.35	0.785	
Costa et al. [8]	231	NA	230	NA	----	-----	------	
Marandi and Chandan, [14]	31	0 0.0%	31	3 9.6%	0.12 (0.01-1.61)	1.22	0.258	
Pooled					0.69 (0.3-1.61)	0.84	0.41	

Table 6: Tendinitis and numbness distribution between groups

Study	Plate		K wire		OR (CI 95%	Z	P	
	N	N %	N	N %				
Hull et al. [9]	36	12 33.3%	35	4 11.4%	2.58 (1.05-7.2)	5.25	0.04*	
Campochiaro et al. [10]	38	2 5.2%	35	1 2.8%	1.56 (0.87-8.3)	2.41	0.063	
Goehre et al. [11]	21	NA	19	NA	----	------	--------	
Brennan et al. [12]	151	2 1.3%	167	1 0.5%	1.23 (0.84-5.2)	2.12	0.085	
Żyluk et al. [13]	30	NA	72	NA	----	------	--------	
Costa et al. [8]	231	NA	230	NA	----	-----	------	
Marandi and Chandan, [14]	31	NA	31	NA	----	------	--------	
Pooled					1.32 (0.7-6.32)	1.63	0.26	

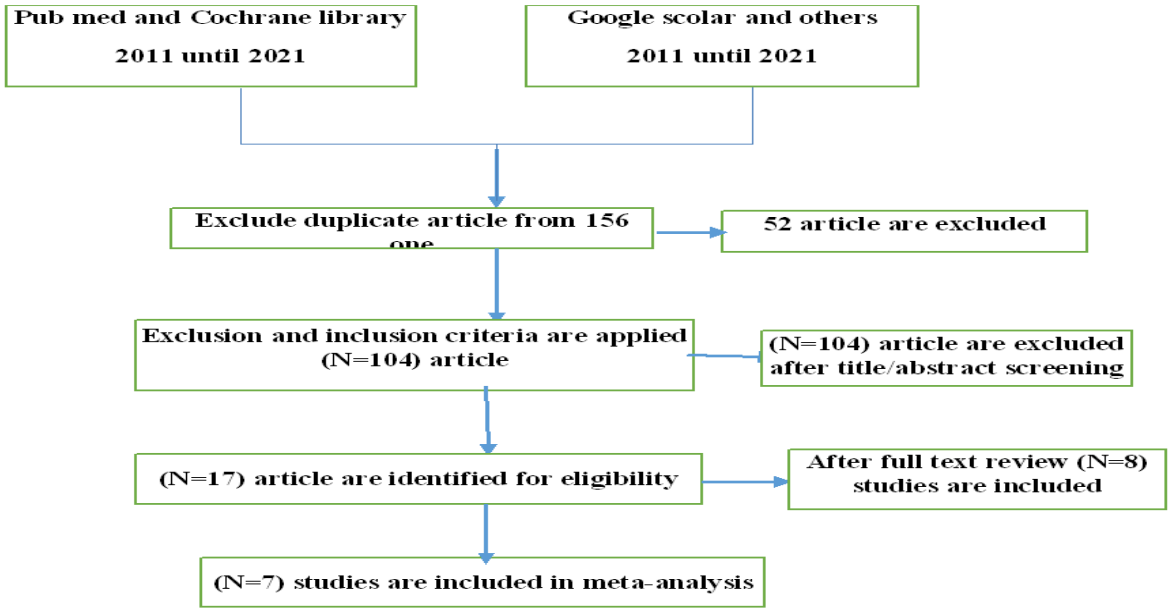

Figure 1. Flow diagram for study selection

DISCUSSION

In the present study, socio demographic distribution as mean age from all studied was 52.89 ± 14.88 and female were majority with average percentage of 75.73% and male 24.27%.

***A.* DASH distribution:**

In the current study, DASH was significantly higher among cases managed by K wire in all studies except Costa et al. [8]. In pooled analysis, DASH was also significantly higher among K wire. It was discovered that there was homogeneity among research. After quantifying these factors, no bias accounted for variations in results between studies which were not due to chance. We discovered no substantial heterogeneity and found agreement among the studies.

It is possible that the higher DASH scores for patients with K-wire fixation during the initial postoperative period are attributed to a delay in the initiation of wrist ROM activities. As a result, the VLP fixation approach could be considered

for patients who require a quicker return to function following injury.

In case of Zong et al. [6] study, among the seven studies included in their review, the DASH score was one of the most regularly reported functional outcome measures. Patients who were managed with VLP fixation had significantly lower DASH ratings throughout a 1-year post-operative period than patients who were managed with percutaneous K-wire fixation. This difference in score was most noticeable during the first three postoperative months followed by a consistent trend for the remaining assessment time points.

Global hand function was assessed using the DASH score, an upper limb functional evaluation scoring method. The DASH is a 30-item validated self-report questionnaire designed to assess physical function and symptoms in patients with upper limb musculoskeletal illnesses. The overall score ranges from '0', indicating normal upper limb use, to '100,' indicating a nonfunctional upper limb [9].

B. PRWE distribution:

In the current study, in pooled analysis, patient rated wrist evaluation did not differ significantly between groups. It was discovered that there was homogeneity among research. After quantifying these factors, no bias accounted for variations in results between studies that are not due to chance. We discovered no substantial heterogeneity and found agreement among the studies.

Brennan et al. [12] showed that the score was not significantly different between methods of treatment (p=0.69 for PRWE). No significant differences in the score were found whether the dominant hand is injured or not (PRWE score, p = 0.41). In Costa et al. [8] study, the results demonstrated that there was no evidence to substantiate group differences in the major outcome measure of PRWE. Longitudinal analysis of the PRWE scores revealed that therapy (LRT p= 0.550) had no influence on outcome.

C. Duration of surgery distribution:

The duration of surgery in VLP was substantially longer in pooled analysis of the current study. There was a lot of consistency in the research. No bias compensated for discrepancies in outcomes between studies that were not due to chance after measuring these factors. There was no significant variability among the studies, and all are agreed.

Goehre et al. [11] reported that the median skin-to-skin operation time in the plate fixation group was 60 (range 31–130) minutes compared to 23 (range 10–55) minutes in the K-wire fixation group with a substantially broader variety of timings for the former. The operation timeframes for the two surgical procedures were significantly different (p 0.01).

D. Complications:

Infection distribution between the two studied group population showed, regarding pooled analysis, no significant difference between two techniques with pooled OR 0.69 (0.3-1.61). Regarding pooled analysis, tendinitis and numbness distributed with no significant difference between the two techniques with pooled OR 1.32 (0.7-6.32). Complex regional pain trauma distribution distributed with no significant difference between the two techniques with pooled OR 0.58 (0.11-2.9). Regarding pooled analysis of CTS distribution, there was no significant difference between the two techniques with pooled OR 0.86 (0.41-2.13).

Zong et al. [6] reviewed seven RCTs on the distal radial fracture fixation and included data on the frequencies of postoperative complications in their study such as superficial infection, deep infection, CRPS, CTS, fracture recurrence, nerve and tendon injury, loss of reduction, additional surgery for hardware removal, pin migration, and revision. A meta-analysis of overall treatment impact found that patients with K-wire fixation had a substantially higher risk of total complications as compared to patients with VLP fixation. In patients with K-wire fixation, the frequency of superficial infection was substantially higher than in individuals with VLP fixation. While the rates of CRPS, nerve injury, tenosynovitis, and loss of reduction were not substantially different between the two types of fixation procedures, patients treated with VLP

fixation had a lower overall incidence of these problems.

In the study of Campochiaro et al. [10], regarding complications in group of ORIF technique with volar plate, they documented two cases of post-operative carpal tunnel syndrome and one post-operative hematoma both of which were surgically addressed with no infection, neurovascular damage, or screw mobilizations. Plate removal was also performed in three patients (7.7 percent) due to intolerance. They also documented one instance of carpal tunnel syndrome cured with medical treatment, one case of wire skin pressure sores, and one case of algo dystrophy in a group with percutaneous Kirschner wires with no peripheral neurovascular impairments or infection.

According to the findings of our meta-analysis, VLP may be a superior fixation approach for the clinical therapy of DDDRF when compared to typical K-wire fixation. However, both Shyamalan [15] and Dzaja [16] discovered that the cost of VLP was two to threefold more than that of K-wire fixation. Surgeons must consider all evidence while deciding on the best DDDRF treatment in consultation with the patient. In orthopedics, we support the concept of shared decision making. In identifying the most effective treatment method, the surgeon must offer patients with evidence-based information on the risks and benefits of the two surgical fixation approaches, taking into account the patient's expectations, lifestyle, and accompanying injuries [17].

CONCLUSION

Locking plate systems should be used to treat unstable intra-articular radius fractures that cannot be reduced or held reduced with pinning. For simple fracture patterns, K wire remains a straightforward and low-cost solution. More randomized control trial study (RCTs) with large sample size about displaced distal radius fracture are needed for more assessment. More rigorously powered multicenter RCTs for confirmation are needed.

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Table S1: CRPT distribution between groups

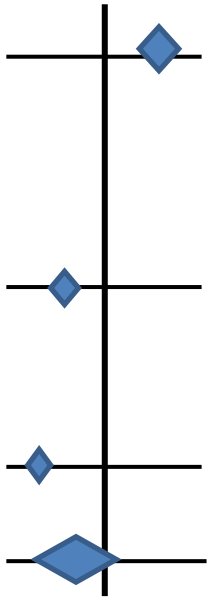
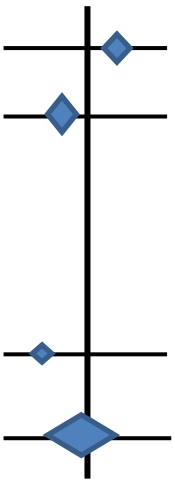
Study	Plate		K wire		OR (CI 95%	Z	P	
	N	N %	N	N %				
Hull et al. [8]	36	NA	35	NA	----	------	------	
Campochiaro et al. [9]	38	2 7.8%	35	1 2.8%	1.88 (0.15-21.1)	0.51	0.61	
Goehre et al. [10]	21	NA	19	NA	----	------	------	
Brennan et al. [11]	151	NA	167	NA	----	------	------	
Żyluk et al. [12]	30	0 0.0%	72	2 2.7%	0.46 (0.02-9.9)	0.51	0.61	
Costa et al. [13]	231	NA	230	NA	----	-----	------	
Marandi and Chandan, [14]	31	0 0.0%	31	3 9.6%	0.12 (0.01-2.65)	1.22	0.258	
Pooled					0.58 (0.11-2.9)	0.84	0.41	

Table S2: Carpal tunnel syndrome distribution between groups

Study	Plate		K wire		OR (CI 95%	Z	P	
	N	N %	N	N %				
Hull et al. [8]	36	NA	35	NA	----	-----	------	
Campochiaro et al. [9]	38	NA	35	NA	----	------	--------	
Goehre et al. [10]	21	3 14.2%	19	2 10.5%	1.4 (0.42-10.2)	0.36	0.72	
Brennan et al. [11]	151	6 2.6%	167	8 4.1%	0.85 (0.36-5.6)	0.35	0.73	
Żyluk et al. [12]	30	NA	72	NA	----	-----	------	
Costa et al. [13]	231	NA	230	NA	----	-----	------	
Marandi and Chandan, [14]	31	0 0.0%	31	1 9.6%	0.36 (0.12-2.36)	0.68	0.321	
Pooled					0.86 (0.41-2.13)	0.31	0.75	