Open versus arthroscopic surgical treatment for anterior shoulder dislocation. A comparative systematic review and meta-analysis over the past 20 years

Running Title: Open or arthroscopic shoulder stabilisation

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Abstract

Hypothesis:

The purpose of this study was to perform a meta-analysis comparing open and arthroscopic surgery for the treatment of anterior shoulder instability, by analysing comparative studies during two different time intervals over the last 20 years.

Methods:

We conducted a systematic review of Medline, Embase, Scopus, and Google Scholar. Two groups were created by dividing studies according to the year of publication, either published 1995-2004 or published 2005-2015. Publication bias and risk of bias was assessed using the Cochrane Collaboration's tools. Heterogeneity was assessed using χ^2 and I_2 statistics.

Results:

A total of 22 studies (n=1633) met the eligibility criteria. Comparison of the pooled estimate for all these studies demonstrated no significant differences (p=0.64) in clinical outcomes between open and arthroscopic shoulder stabilization. However, studies published from 1995 through 2004 demonstrated significant differences (p=0.015) in recurrence rates. In contrast, no significant differences (p=0.09) in recurrence rates were observed for studies published from 2005 through 2015. The pooled estimate for all studies in both groups demonstrated significant differences (p=0.001) in external rotation deficits between open and arthroscopic shoulder stabilization favouring arthroscopic surgery.

Conclusion:

Despite advances in surgical techniques and devices over the last 20 years, either open or arthroscopic surgical treatment of anterior shoulder dislocation results in similar clinical outcomes. The recurrence rate for arthroscopic surgical stabilisation has only

marginally decreased from 16.8% to 14.2%. However, during the earlier decade from 1995 through 2004 patients treated with arthroscopic surgery had twice the risk of recurrence compared to an open procedure.

Keywords:

anterior shoulder dislocation; open Bankart repair; arthroscopic stabilisation; suture anchors, meta-analysis; systematic review;

Level of evidence

Level 4; systematic review and meta-analysis

Introduction

Traumatic anterior shoulder dislocations are common with a reported incidence in the United States of 23.9 per 100,000 persons per year, twice as much as previously reported [44] . More than 90% of these traumatic dislocations occur in an anterior-inferior direction [13] . The recurrence rate reportedly approaches 90% in young active patients [1,26,33] . Early surgical treatment reduces recurrence rates and improves functional outcomes in young adults engaged in physical activities [2,25,26] . The overall goal of treatment is to repair the capsulolabral-ligamentous complex in order to restore glenohumeral stability [6] , and surgical intervention reduces the risk of recurrence to only 6 to 23% [1,17] .

Open Bankart repair was previously considered the standard of care, resulting in recurrence rates below 10% [35] . Advocates of open surgery argue that a more anatomic and secure repair can be accomplished [6] . However, muscle weakness, secondary osteoarthritis, and restriction of glenohumeral joint motion, particularly external rotation, were inevitable sequelae of this procedure [35,43] .

Arthroscopic shoulder stabilization methods have evolved significantly over the past 25 years [12] . Initial techniques included trans-glenoid suturing with reported failure rates as great as 49% [10,12] , and bioabsorbable tack fixation with failure rates of up to 23% [8,10,12] . However, newer techniques using suture anchors and capsular plication have reported failure rates of only 8-11% [12] . Based on these observations, it has been suggested that suture anchors should be considered the gold standard for fixation in shoulder stabilization, and when compared to open surgery using the same technique, similar results were achieved arthroscopically [4] . Arthroscopic procedures can potentially avoid many of the complications associated with open surgery such as infection, subscapularis weakness and ruptures, arthrofibrosis, and reduced range of motion [6] . Arthroscopic Bankart repairs are increasingly used, and have increased in the United States from 71.2% of all the cases in 2004, to 89% in 2009, doubling in incidence indicating a paradigm shift [46] . Given the increased surgical experience and advances with arthroscopic techniques over the last decade, recurrence and failure rates should have substantially decreased, as well as being similar to open surgery outcomes.

The purpose of this study was therefore to perform a meta-analysis between open and arthroscopic surgical techniques for the treatment of anterior shoulder instability, by analysing comparative studies during two separate and distinct time intervals over the last 20 years. We hypothesized that there would be similar clinical outcomes, but a significant reduction in failure and recurrence rates with arthroscopic techniques, and that this effect would be most evident during the more recent time period analysed.

Methods

The research was conducted according to the methods described in the Cochrane Handbook [16] . The results are reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines statement [29] .

Eligibility criteria

All studies that compared arthroscopic stabilization to open Bankart repair in patients between 18 to 60 years of age, from 1995 to 2015 were identified and considered for inclusion. Studies reporting on bone block procedures such as Latarjet and Bristow coracoid transfers or bone grafting such as j-span or osteotomies were excluded. Further studies including subluxation,anterior instability or positive apprehension were also excluded.

This included retrospective and level IV case series, if both treatments were described. Included studies had to have at least one validated outcome score (Constant, Rowe, WOSI, UCLA, ASES, SANE, DASH) with complete documentation in tables or main text describing demographic and surgical details, with a minimum of two years follow-up. Studies were excluded if patients had revision surgery, were only an abstract or conference proceedings, case reports, or were in-vitro and basic science papers. It is acknowledged that the omission of these “grey” data could potentially result in publication bias.

Literature research

We performed a systematic review of the literature to identify all publications in the English and German literature dealing with anterior shoulder instability and/or dislocation. The databases Medline, Embase, Scopus and Google Scholar were systemically searched using the terms and Boolean operators: "anterior shoulder" AND "shoulder dislocation" AND/OR "shoulder instability"; "open" AND "arthroscopic" AND/OR "shoulder stabilization OR "Bankart". Two reviewers conducted independent title and abstract screening. Disagreements between reviewers were resolved by consensus, and if no consensus was reached, they were carried forward to the full text review. All eligible articles were manually cross-referenced to ensure that other potential studies were included.

Data extraction and quality assessment

An electronic data extraction form was used to obtain the following data from each article: mean age, gender, sample size, surgical technique and fixation method, length of follow-up, outcome scores, level of evidence, external rotation deficit, recurrence rates, and return to sports (if applicable). The senior author independently completed data extraction, and the second reviewer verified the data.

Risk of bias was assessed using the Cochrane Collaboration's Risk of Bias Tool [16] . The GRADE system was used by the senior author to assess the quality of the body of evidence for each outcome measure; the second reviewer verified the assessments. The recommendations from the Cochrane Handbook were followed, and studies were downgraded if there were limitations in the design, indirectness of evidence, unexplained heterogeneity, imprecision of results, and high probability of publication bias. All institutional and author information was concealed to the second reviewer to reduce reviewer bias. Any disagreement between reviewers was resolved by a consensus and/or by arbitration between the two senior authors.

Statistical analysis

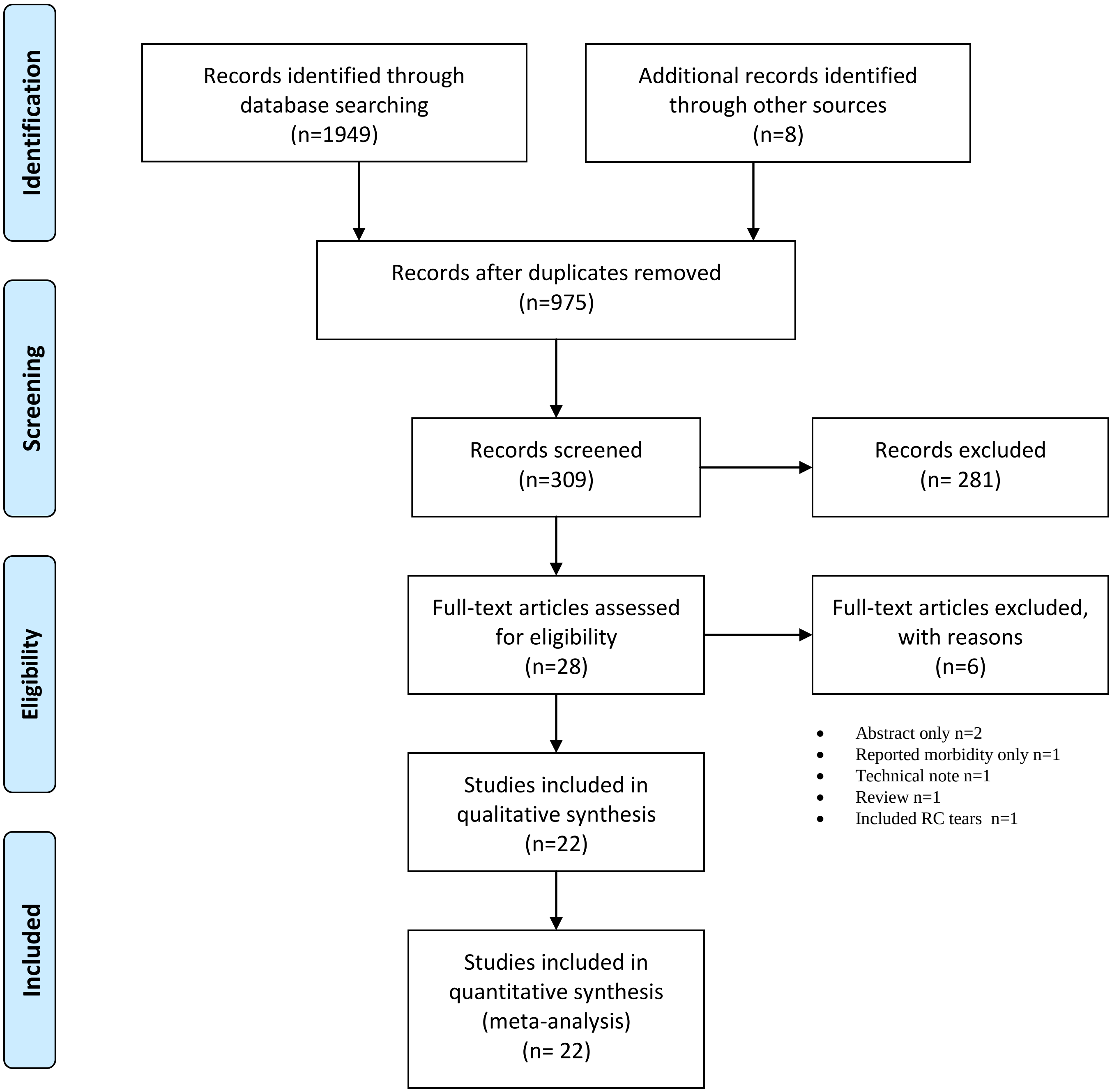
Inter-observer differences for study eligibility and risk of bias were measured using Cohen's kappa coefficient. Heterogeneity of the data was assessed using χ^2 and I_2 statistics. Outcomes were pooled using a random effects model if the I_2 statistic was >50%; however, if it was <50% then a fixed effect model was utilized. If standard deviations were not reported the standard deviation was calculated using the following formula: SD= max-min/4. Hozo, et al. have shown that this formula provides a good estimation of standard deviation [19] . The results of the categorical outcome recurrence were pooled and analysed using a 2x2 contingency table and a Chi-Square test, or Fisher's exact test if the sample size in any category was <5. All tests of significance were two-tailed, and an α of less than 0.05 was considered significant. Publication bias was assessed using funnel plots. Funnel and forest plots, as well as all statistical analyses, were performed using STATA SE (Version 12.0; StataCorp, College Station, Texas, USA) for Windows, and the comprehensive meta-analysis software package (CMA), version 3 (Biostat Inc, Englewood, NJ, USA).

Results

Study selection and characteristics

The literature search identified 1,957 studies for consideration; however, only 28 were eligible for inclusion. Examination of these full text manuscripts was conducted, and

Figure 1: PRISMA Flow Diagram



only 22 studies met all of the eligibility criteria to be included in the analysis [3,7,9,11,14,20-24,27,28,30,31,33,34,38-42,45] (Figure 1).

Overall agreement between the two reviewers for final eligibility was excellent (kappa value 0.92, 95% CI 0.89-0.93). All 22 studies were published in English between 1996 and 2014, with a cumulative total of 1,633 cases. There were a total of 817 patients treated with arthroscopic techniques and 816 with open repair. The number of total cases treated during 1995-2004 increased from 295 to 854 between 2005 and 2015; a 290% increase of reporting. The study characteristics are summarized in Table 1.

Risk of bias

The findings of the bias risk assessment are summarized in Table 2. Of the eight prospective randomized studies, three studies [3,20,27] were found to have a high risk and one study a questionable risk [21] of random sequence generation and allocation concealment. Because the nature of comparing open versus arthroscopic techniques resulted in a high risk of bias for blinding of participants and personnel, the outcome assessments were assessed as high risk for all included studies. Attrition bias was assessed as questionable in twelve of the twenty-one studies [9,11,14,20,23,27,28,31,38,40,41,45], and was clearly present in three more studies [30,34,42]. This assessment was mainly based on the lack of reporting on how many patients were lost to follow-up. None of the studies were assessed to have reporting bias. Other bias was assessed in eleven studies [3,11,14,22,23,24,27,28,33,41,45] and four studies [9,30,34,42] had an uncertain risk of other bias. The main concern was the change of surgical techniques over the study period, inclusion of adolescent patients or other special population groups (military,

Table 1: Patient Demographics and Study Characteristics of Included Studies

		Number of patients and surgical technique		Age		Gender m/f		Follow-up (in months)	
Study	Year	Arthroscopic	Open	Arthroscopic	Open	Arthroscopic	Open	Arthroscopic	Open
Guanche [14]	1996	15 Mitek, Tranglenoid	12 Mitek, Transglenoid	28	29	N/A	N/A	27	25
Geiger [11]	1997	16 Caspari	18 Rowe	26	25	14/2	25	34	23
Steinbeck [40]	1998	30 Morgan	32 Mitek	27.5	29.7	23/7	28/4	36	40
Kartus [23]	1999	18 Suretac	18 Suretac	N/A	N/A	N/A	N/A	28	31
Roberts [34]	1999	21 Suretac, suture anchors	24 Suretac suture anchors	19.9	19.9	N/A	N/A	29.4	29.4
Jorgensen [21]	1999	21 Morgan	20 Mitek	28	28	15/6	15/5	36.2	36.6
Cole [7]	2000	37 suretac	22 Neer	28	27	33/4	18/4	52	55
Karlsson [22]	2001	60	48	26	27	45/15	38/10	28	36
Sperber [38]	2001	30 Suture anchors/tacks	26 Suture anchors/tacks	25	27.5	21/9	19/7	24	24
Kim [24]	2002	58	30	19.5	20.3	50/8	26/4	39	39

Table 2: Risk of Bias

	Random Sequence Generation (Selection Bias)	Allocation Concealment (Selection Bias)	Blinding of Participants and Personnel (Performance Bias)	Blinding of Outcome Assessment (Detection Bias)	Incomplete Outcome Data (Attrition Bias)	Selective reporting (Reporting Bias)	(Other Bias)
Bottoni et al., 2006 [3]	−	−	−	?	+	+	−
Rhee et al. 2006 [33]	*	*	−	?	+	+	−
Tjoumakaris et al., 2006 [41]	**	**	−	−	?	+	−
Lützner et al., 2009 [27]	−	−	−	−	?	+	−
Mahirogullari et al., 2010 [28]	**	**	−	−	?	+	−
Zaffagnini et al., 2012 [45]	**	**	−	−	?	+	−
Netto et al., 2012 [31]	+	+	−	?	?	+	+
Mohtati et al., 2014 [30]	+	+	−	−	−	+	?
Sperling et al., 2005 [39]	*	*	−	−	+	+	+
Wang et al., 2005 [42]	**	**	−	?	−	+	?
Fabbriciani et al., 2004 [9]	+	+	−	?	?	+	?
Hubell et al., 2004 [20]	−	−	−	−	?	+	+
Kim et al., 2002 [24]	*	*	−	−	+	+	−
Karlsson et al., 2001 [22]	***	***	−	−	+	+	−
Cole et al., 2000 [7]	*	*	−	−	+	+	+
Sperber et al., 2001 [38]	+	+	−	−	?	+	+
Roberts et al., 1999 [34]	*	*	−	−	−	+	?
Jorgensen et al., 1999 [21]	?	?	−	−	+	+	+
Steinbeck et al., 1998 [40]	***	***	−	−	?	+	+
Kartus et al., 1998 [23]	***	***	−	−	?	+	−
Geiger et al. 1997 [11]	***	***	−	+	?	+	+
Guanche et al., 1996 [14]	*	*	−	−	?	+	−

*Cohort study, level IV

**retrospective comparative study, level III

***prospective non randomized study level II

Fabbriciani [9]	2004	30	30	24.5	26.8	24/6	26/4	24	24
Hubell [20]	2004	30 Caspari	20 Bankart	24.5	27	20/10	13/7	60	60
Sperling [39]	2005	5 Caspari	6 Caspari	57.8	56	1/4	4/2	66	66
Wang [42]	2005	22 Mitek suture anchors	20 transosseous	35	23	N/A	N/A	24	24
Bottoni [3]	2006	32 Bio Fastak	29 Bio Fastak	25.2	25.1	31/1	29/0	30	28.5
Rhee [33]	2006	16 Suretac (4) Mini Revo (12)	32 Matsen	20.4*	20.4*	N/A	N/A	66.8	73.8
Tjoumakaris [41]	2006	59 Bio Fastak	24 Bio Fastak	30.8	28	48/11	16/8	40	56
Lützner [27]	2009	40 Fastak, Mini Revo, Mitek	159 Fastak, Mini Revo, Mitek	25	27	35/5	124/35	21	31
Mahirogullari [28]	2010	34 Metal suture anchors	30 Metal suture anchors	24.9	25.8	34	30	26.1	26.6
Zaffagnini [45]	2012	49 Caspari	33 Rowe	35	38	N/A	N/A	164.4	188.4
Netto [31]	2012	17 2mm metal Hexagon	25 Matsen	27.5	30.8	16/1	21/4	37.5*	37.5*
Mohtati [30]	2014	98 Suture anchor	98 Suture anchor	27.2	27.8	80/18	80/18	24	24

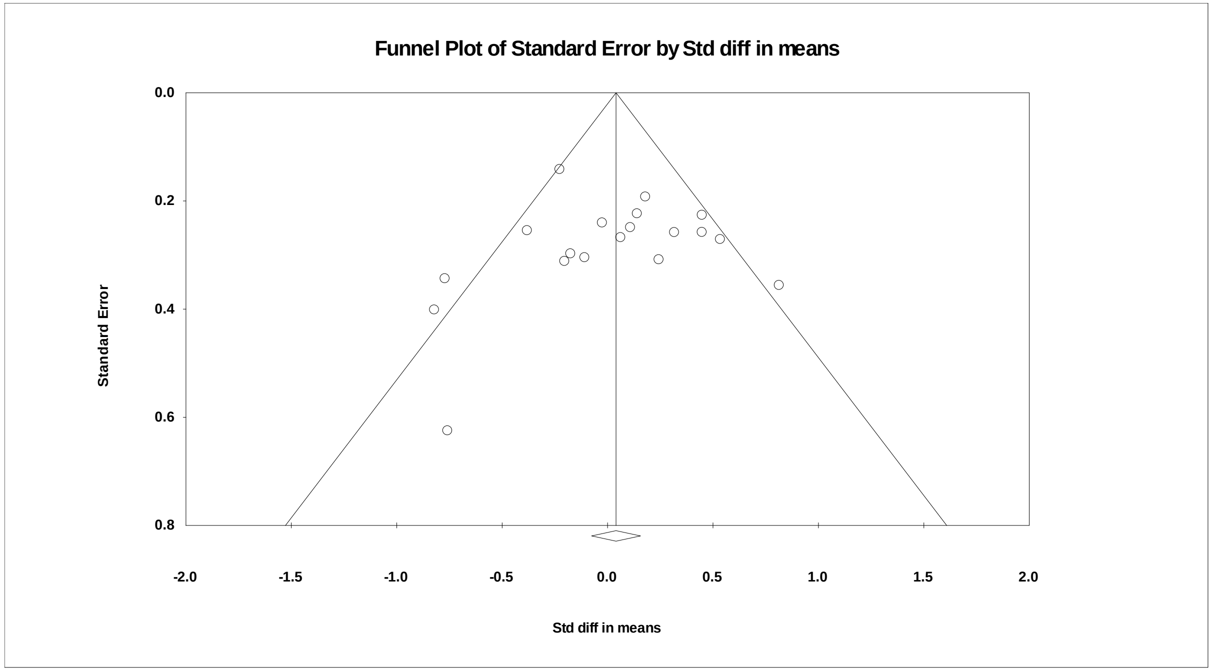


Figure 2: The distribution of the 22 included studies is symmetric and does not suggest publication bias.

professional athletes), and different surgical techniques between the open and closed groups. Although the funnel plot appeared symmetric on visual inspection, three studies were clearly outside the standard error, but did not suggest publication bias (Figure 2). Using the GRADE quality assessment for clinical outcome and recurrence rates the quality of evidence for this study was therefore double downgraded, and considered to be of lower quality due to unexplained heterogeneity of all studies included.

Clinical outcome

Functional outcome was measured by the Rowe score in fifteen studies , the Constant score in six, the UCLA shoulder score in five, and the ASES shoulder score in four (Table 3). The pooled estimate for all studies from 1995 through 2015 demonstrated no significant differences in clinical outcomes between open and arthroscopic shoulder stabilization (SMD 0.03, 95% CI: -0.165 to 0.229, p=0.74, I_2= 55.4%; Figure 3). For those studies published during the period from 1995 through 2004 the pooled estimate demonstrated no significant differences in clinical outcomes between open and arthroscopic shoulder stabilization (SMD 0.02, 95% CI: -0.169 to 0.209, p=0.83, I_2= 18.6%) (Figure 4). Similarly, for those studies published during the period from 2005 through 2015 the pooled estimate demonstrated no significant differences in clinical outcomes between open and arthroscopic shoulder stabilization (SMD 0.04, 95% CI: -0.126 to 0.206, p=0.64, I_2= 54.7%; Figure 5).

Recurrence

Recurrence rates were reported by all studies and are summarized in table 3. The pooled estimate for all studies from 1995 through 2015 demonstrated no significant

Meta-Analysis: Clinical Outcomes for all included studies from 1995 until 2015

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight
Guanche 1996	-0.817	0.403	0.162	-1.607	-0.028	-2.028	0.043	3.28	
Geiger 1997	0.818	0.358	0.128	0.117	1.519	2.288	0.022	3.87	
Steinbeck 1998	-0.377	0.256	0.066	-0.879	0.126	-1.470	0.142	5.71	
Kartus 1999	-0.767	0.345	0.119	-1.444	-0.090	-2.220	0.026	4.05	
Jorgensen 1999	-0.199	0.313	0.098	-0.813	0.415	-0.636	0.525	4.58	
Roberts 1999	-0.171	0.299	0.090	-0.758	0.416	-0.571	0.568	4.83	
Cole 2000	0.067	0.269	0.073	-0.461	0.594	0.248	0.804	5.43	
Sperber 2001	0.539	0.273	0.074	0.004	1.074	1.976	0.048	5.35	
Karlsson 2001	0.184	0.194	0.038	-0.196	0.564	0.948	0.343	7.26	
Kim 2002	0.145	0.225	0.051	-0.297	0.586	0.643	0.520	6.45	
Fabbriciani 2004	0.322	0.260	0.068	-0.188	0.831	1.238	0.216	5.63	
Wang 2005	0.248	0.310	0.096	-0.360	0.856	0.800	0.424	4.63	
Sperling 2005	-0.754	0.627	0.393	-1.982	0.474	-1.204	0.229	1.63	
Bottoni 2006	0.452	0.260	0.067	-0.057	0.961	1.742	0.082	5.64	
Rhee 2006	-0.104	0.306	0.094	-0.704	0.496	-0.339	0.734	4.70	
Tjoumakis 2006	-0.021	0.242	0.059	-0.495	0.454	-0.086	0.931	6.04	
Mahirogullari 2010	0.112	0.251	0.063	-0.379	0.604	0.449	0.654	5.84	
Zaffagnini 2012	0.453	0.228	0.052	0.006	0.899	1.986	0.047	6.38	
Mohtati 2014	-0.222	0.143	0.021	-0.503	0.058	-1.552	0.121	8.72	
	0.043	0.086	0.007	-0.127	0.212	0.494	0.621		

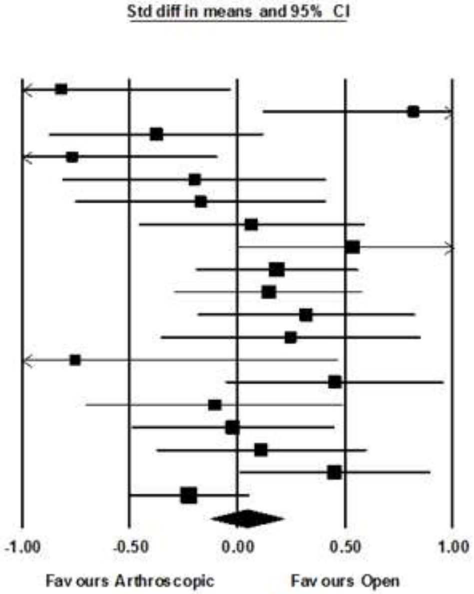


Figure 3: The pooled estimated for all studies from 1995 through 2015 demonstrated no significant differences (p=0.62) in clinical outcomes.

Meta-Analysis: Clinical Outcomes for all included studies from 1995 until 2015

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight
Guanche 1996	-0.817	0.403	0.162	-1.607	-0.028	-2.028	0.043	3.28	
Geiger 1997	0.818	0.358	0.128	0.117	1.519	2.288	0.022	3.87	
Steinbeck 1998	-0.377	0.256	0.066	-0.879	0.126	-1.470	0.142	5.71	
Kartus 1999	-0.767	0.345	0.119	-1.444	-0.090	-2.220	0.026	4.05	
Jorgensen 1999	-0.199	0.313	0.098	-0.813	0.415	-0.636	0.525	4.58	
Roberts 1999	-0.171	0.299	0.090	-0.758	0.416	-0.571	0.568	4.83	
Cole 2000	0.067	0.269	0.073	-0.461	0.594	0.248	0.804	5.43	
Sperber 2001	0.539	0.273	0.074	0.004	1.074	1.976	0.048	5.35	
Karlsson 2001	0.184	0.194	0.038	-0.196	0.564	0.948	0.343	7.26	
Kim 2002	0.145	0.225	0.051	-0.297	0.586	0.643	0.520	6.45	
Fabbriciani 2004	0.322	0.260	0.068	-0.188	0.831	1.238	0.216	5.63	
Wang 2005	0.248	0.310	0.096	-0.360	0.856	0.800	0.424	4.63	
Sperling 2005	-0.754	0.627	0.393	-1.982	0.474	-1.204	0.229	1.63	
Bottoni 2006	0.452	0.260	0.067	-0.057	0.961	1.742	0.082	5.64	
Rhee 2006	-0.104	0.306	0.094	-0.704	0.496	-0.339	0.734	4.70	
Tjoumakis 2006	-0.021	0.242	0.059	-0.495	0.454	-0.086	0.931	6.04	
Mahirogullari 2010	0.112	0.251	0.063	-0.379	0.604	0.449	0.654	5.84	
Zaffagnini 2012	0.453	0.228	0.052	0.006	0.899	1.986	0.047	6.38	
Mohtati 2014	-0.222	0.143	0.021	-0.503	0.058	-1.552	0.121	8.72	
	0.043	0.086	0.007	-0.127	0.212	0.494	0.621		

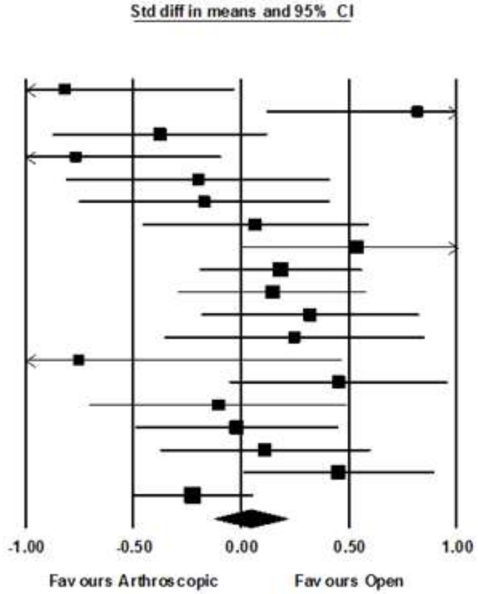


Figure 4: The pooled estimated for all studies from 1995 through 2004 demonstrated no significant differences (p=0.62) in clinical outcomes.

Meta-Analysis: Clinical Outcomes for all included studies from 2005 until 2015

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Wang 2005	0.248	0.310	0.096	-0.360	0.856	0.800	0.424	7.46
Sperling 2005	-0.754	0.627	0.393	-1.982	0.474	-1.204	0.229	1.83
Bottoni 2006	0.452	0.260	0.067	-0.057	0.961	1.742	0.082	10.65
Rhee 2006	-0.104	0.306	0.094	-0.704	0.496	-0.339	0.734	7.65
Tjoumakis 2006	-0.021	0.242	0.059	-0.495	0.454	-0.086	0.931	12.24
Mahirogullari 2010	0.112	0.251	0.063	-0.379	0.604	0.449	0.654	11.42
Zaffagnini 2012	0.453	0.228	0.052	0.006	0.899	1.986	0.047	13.81
Mohtati 2014	-0.222	0.143	0.021	-0.503	0.058	-1.552	0.121	34.95
	0.040	0.085	0.007	-0.126	0.206	0.472	0.637	

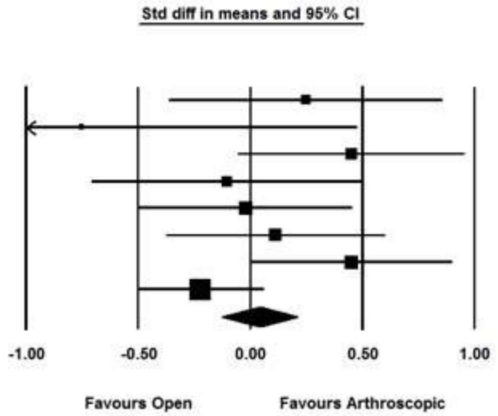


Figure 5: The pooled estimated for all studies from 2005 through 2015 demonstrated no significant differences (p=0.64) in clinical outcomes.

Table 3. Docking results and binding free energy (kcal/mol) of acarbose and the selected peptides with the C-terminal of human α-glucosidase

Peptide ligand	Binding energy (kcal/mol)	Number of hydrogen bonds	Interacting residue of the peptide	Interacting residue of the α-glucosidase	Hydrogen bond distance (Å)
Acarbose	-7.6	3	-	-	-
SQSPA	-6.4	2	S1	D1117	2.410
			S1	G1209	2.488
STYV	-7.0	4	S1	G1209	2.509
			T2	K1059	2.733
			S1	Y1062	2.137
			Y3	N1480	2.267
STY	-7.2	6	S1	E1640	2.409
			Y3	I1716	2.427
			T2	K1625	2.187
			Y3	R1635	2.077
			Y3	R1635	2.206
			Y3	R1635	1.972

Meta-Analysis: Recurrence rates for all studies from 1995 until 2015

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Guanche 1996	5.500	0.545	55.494	1.445	0.148	2.52
Geiger 1997	6.222	1.059	36.566	2.023	0.043	4.29
Steinbeck 1998	1.600	0.276	9.261	0.525	0.600	4.37
Jorgensen 1999	0.947	0.120	7.457	-0.051	0.959	3.16
Roberts 1999	3.077	0.767	12.336	1.586	0.113	6.98
Cole 2000	1.935	0.355	10.554	0.763	0.445	4.68
Sperber 2001	2.333	0.536	10.157	1.129	0.259	6.22
Karlsson 2001	0.882	0.268	2.910	-0.206	0.837	9.45
Kim 2002	0.500	0.067	3.738	-0.675	0.499	3.33
Hubell 2004	18.116	0.989	331.714	1.953	0.051	1.59
Wang 2005	0.190	0.019	1.873	-1.422	0.155	2.58
Bottoni 2006	0.435	0.037	5.073	-0.664	0.507	2.23
Rhee 2006	2.333	0.499	10.907	1.077	0.282	5.66
Tjoumakis 2006	0.397	0.024	6.610	-0.644	0.519	1.70
Lutzner	0.144	0.051	0.407	-3.655	0.000	12.46
Mahirogullari 2010	1.813	0.156	21.056	0.475	0.635	2.24
Zaffagnini 2012	2.414	0.555	10.505	1.174	0.240	6.22
Netto 2012	8.226	0.370	182.831	1.332	0.183	1.40
Mohtati 2014	2.536	1.091	5.893	2.162	0.031	18.92
	1.372	0.951	1.981	1.691	0.091	

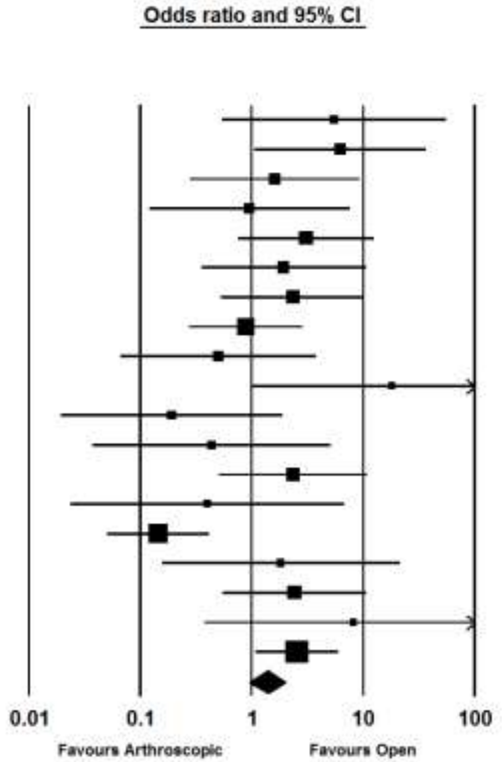


Figure 6: The pooled estimated for all studies from 1995 through 2015 demonstrated no significant differences (p=0.09) for recurrence rates. However the odds ratio of 1.37 suggested that arthroscopic shoulder stabilisation had a 37% higher risk of recurrence.

differences for recurrence rates between open and arthroscopic shoulder stabilization (OR 1.372, 95% CI: 0.951 to 1.981, p=0.091, I_2= 11.9%; Figure 6). The odds ratio of 1.37 favoured open surgery, suggesting the group treated with arthroscopic shoulder surgery had a 37% higher risk of recurrence. In contrast, the pooled estimates for the studies published from 1995 through 2004 demonstrated significant differences for recurrence rates between open and arthroscopic shoulder stabilization (OR 1.964, 95% CI: 1.142 to 3.378, p=0.015, I_2= 6.8%; Figure 7). The odds ratio of 1.964 clearly favoured open surgery, and suggests that in patients treated with arthroscopic shoulder surgery the risk of recurrence doubled when compared to open surgery. However, the pooled estimates for the studies published from 2005 through 2015 demonstrated no significant differences for recurrence rates between open and arthroscopic shoulder stabilization (OR 1.441, 95% CI: 0.730 to 2.844, p=0.29, I_2= 27.8%; Figure 8). The odds ratio of 1.441 favoured open surgery, and suggests arthroscopic shoulder surgery had a 44% higher risk of recurrence.

When comparing the two time intervals for recurrence rates following arthroscopic surgery, χ^2 statistics with Yates corrections revealed that there were no significant differences (χ^2=0.48, p=0.49). In fact, the recurrence decreased marginally from 16.8% (1995-2004) to 14.2% (2005-2015). Similar results were seen when comparing recurrence rates following open surgery, and the χ^2 statistics with Yates corrections revealed that there were no significant differences (χ^2=0.022, p=0.88). The recurrence rates were very similar for both time periods (10.7% between 1995 and 2004, and 10.8% between 2005 and 2015).

Meta-Analysis: Recurrence rates for all studies from 1995 until 2004

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Guanche 1996	5.500	0.545	55.494	1.445	0.148	5.46
Geiger 1997	6.222	1.059	36.566	2.023	0.043	9.25
Steinbeck 1998	1.600	0.276	9.261	0.525	0.600	9.41
Jorgensen 1999	0.947	0.120	7.457	-0.051	0.959	6.84
Roberts 1999	3.077	0.767	12.336	1.586	0.113	14.93
Cole 2000	1.935	0.355	10.554	0.763	0.445	10.07
Sperber 2001	2.333	0.536	10.157	1.129	0.259	13.33
Karlsson 2001	0.882	0.268	2.910	-0.206	0.837	20.06
Kim 2002	0.500	0.067	3.738	-0.675	0.499	7.19
Hubell 2004	18.116	0.989	331.714	1.953	0.051	3.46
	1.964	1.142	3.378	2.441	0.015	

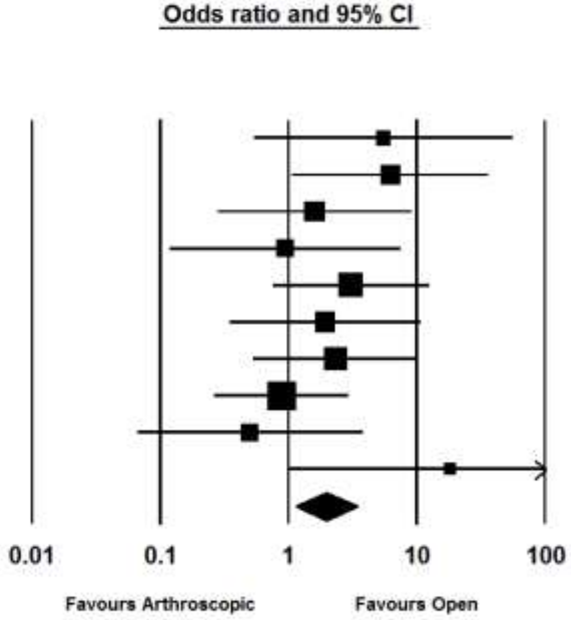


Figure 7: The pooled estimated for all studies from 1995 through 2004 demonstrated significant differences (p=0.01) for recurrence rates. The odds ratio of 1.96 suggested that arthroscopic shoulder stabilisation had a 96% higher risk of recurrence.

Meta-Analysis: Recurrence rates for all included studies from 2004 until 2015

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Bottoni 2006	0.435	0.037	5.073	-0.664	0.507	6.61
Rhee 2006	2.333	0.499	10.907	1.077	0.282	13.83
Tjoumakis 2006	0.397	0.024	6.610	-0.644	0.519	5.20
Lutzner 2009	0.450	0.148	1.372	-1.404	0.160	20.96
Mahirogullari 2010	1.813	0.156	21.056	0.475	0.635	6.62
Zaffagnini 2012	2.414	0.555	10.505	1.174	0.240	14.79
Netto 2012	8.226	0.370	182.831	1.332	0.183	4.37
Mohtati 2014	2.536	1.091	5.893	2.162	0.031	27.62
	1.441	0.730	2.844	1.054	0.292	

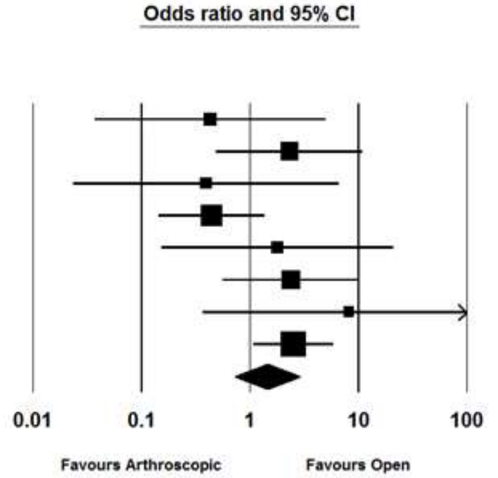


Figure 8: The pooled estimated for all studies from 2005 through 2015 demonstrated no significant differences (p=0.29) for recurrence rates. However the odds ratio of 1.44 suggested that arthroscopic shoulder stabilisation had a 44% higher risk of recurrence.

Meta-Analysis: External Rotation Deficits for all included studies from 1995 until 2015

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Guanche 1996	0.433	0.392	0.153	-0.335	1.201	1.105	0.269	3.61
Geiger 1997	-0.462	0.348	0.121	-1.144	0.220	-1.327	0.185	4.57
Kartus 1999	-1.693	0.388	0.151	-2.454	-0.931	-4.358	0.000	3.67
Cole 2000	-0.237	0.270	0.073	-0.766	0.293	-0.876	0.381	7.59
Sperber 2001	-0.211	0.269	0.072	-0.738	0.316	-0.786	0.432	7.67
Karlsson 2001	-0.461	0.196	0.038	-0.846	-0.077	-2.351	0.019	14.40
Kim 2002	-0.153	0.225	0.051	-0.594	0.289	-0.678	0.498	10.93
Hubell 2004	-1.274	0.316	0.100	-1.892	-0.655	-4.037	0.000	5.57
Sperling 2005	-2.000	0.741	0.548	-3.452	-0.548	-2.701	0.007	1.01
Bottoni 2006	-0.812	0.267	0.071	-1.335	-0.289	-3.045	0.002	7.79
Rhee 2006	-0.211	0.307	0.094	-0.812	0.391	-0.687	0.492	5.88
Mahirogullari 2010	0.481	0.254	0.065	-0.017	0.979	1.894	0.058	8.58
Netto 2012	1.897	0.172	0.030	1.560	2.235	11.030	0.000	18.72
	0.045	0.074	0.006	-0.101	0.191	0.603	0.546	

Std diff in means and 95% CI

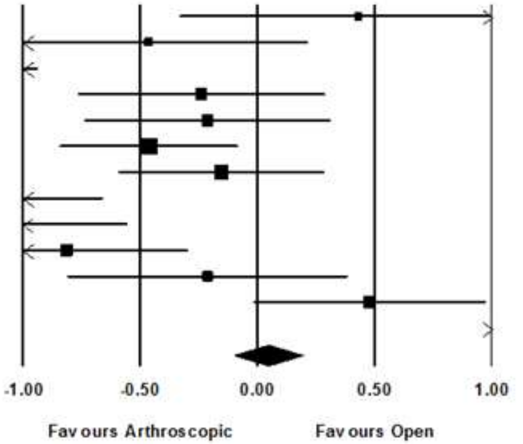


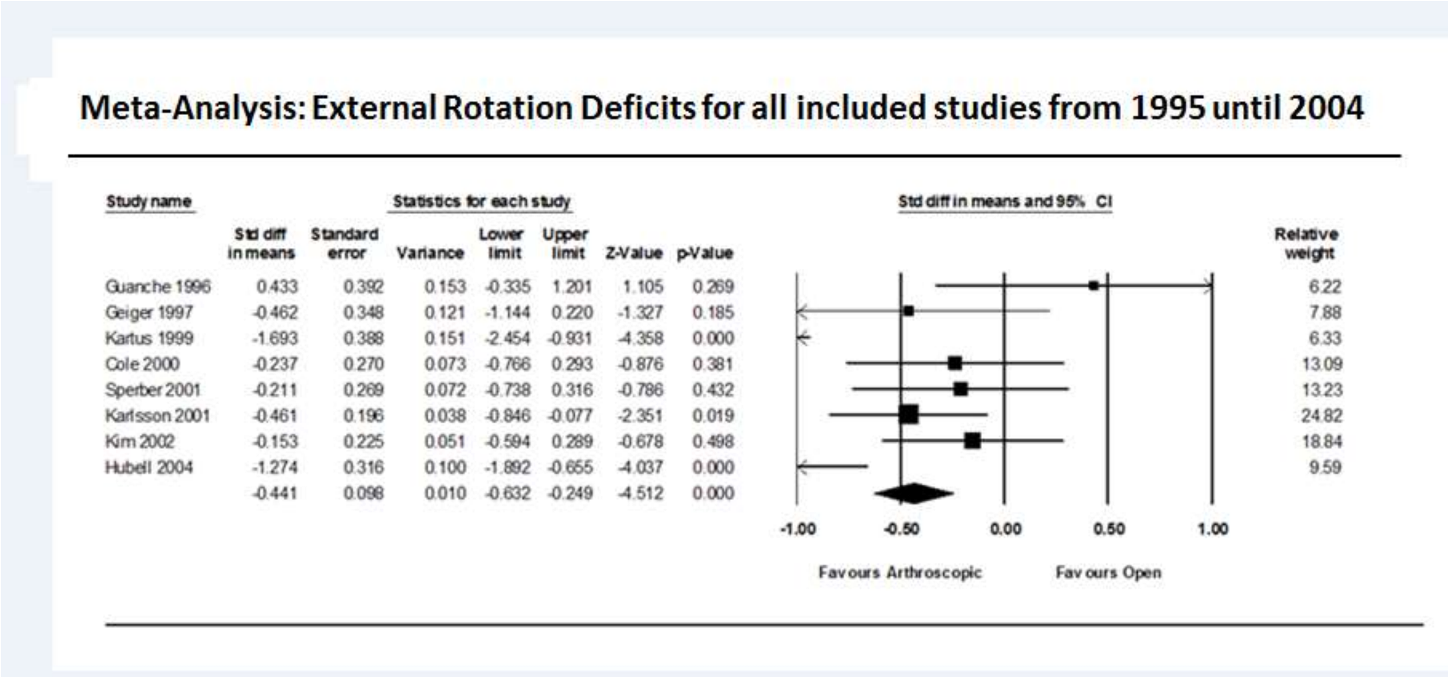
Figure 9: The pooled estimated for all studies from 1995 through 2015 demonstrated no significant differences (p=0.54) for eternal rotation deficits.

Range of Motion- External Rotation Deficit

External rotation deficits were reported by 14 studies [3,7,11,14,20,22,23,24,28,30,31,33,38,39]. The pooled estimate for all studies published from 1995 through 2015 demonstrated no differences in external rotation deficits between open and arthroscopic shoulder stabilization (SMD 0.045, 95% CI: -0.101 to 0.191, p=0.54, I_2= 93.65%; Figure 9). Conversely, for studies included for the period from 1995 through 2004 there were significant differences in external rotation deficits between open and arthroscopic shoulder stabilization (SMD -0.441, 95% CI: -0.632 to -0.249, p=0.001, I_2= 72.3%) where the results favoured arthroscopic surgery (Figure 10). The mean deficit in the arthroscopic group was 5.4 degrees compared to 7.8 degrees in the open surgery group. For studies included for the period published from 2005 through 2015 the pooled data demonstrated significant differences in external rotation deficits between open and arthroscopic shoulder stabilization (SMD 0.716, 95% CI: 0.491 to 0.941, p=0.0001, I_2= 96.1%), and clearly favoured arthroscopic surgery (Figure 11). The mean deficit in the arthroscopic group was 4 degrees compared to 4.4 degrees in the open surgery group, although this is almost certainly not clinically relevant.

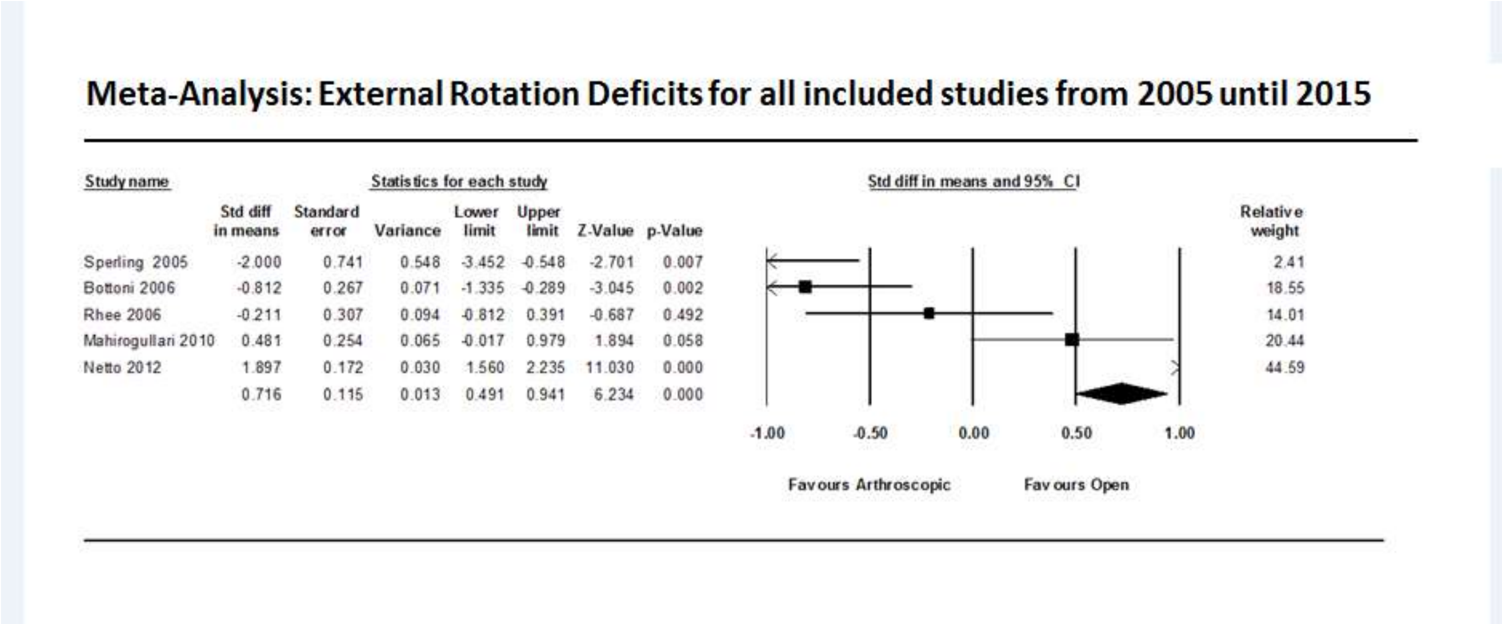
Discussion

The results of this meta-analysis of open versus arthroscopic shoulder stabilization comparing two recent decades demonstrated there were no significant improvements achieved for either clinical outcomes or external rotation deficits. While the recurrence rate for open surgery remained similar (10.7% and 10.8%) during these two periods, recurrence in the arthroscopic stabilization cohort decreased from 16.8 to 14.2%. Statistical analysis revealed that this difference between the two time intervals was not significant and was not clinically relevant. However, for the time period from



Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Guanche 1996	0.433	0.392	0.153	-0.335	1.201	1.105	0.269	6.22
Geiger 1997	-0.462	0.348	0.121	-1.144	0.220	-1.327	0.185	7.88
Kartus 1999	-1.693	0.388	0.151	-2.454	-0.931	-4.358	0.000	6.33
Cole 2000	-0.237	0.270	0.073	-0.766	0.293	-0.876	0.381	13.09
Sperber 2001	-0.211	0.269	0.072	-0.738	0.316	-0.786	0.432	13.23
Karlsson 2001	-0.461	0.196	0.038	-0.846	-0.077	-2.351	0.019	24.82
Kim 2002	-0.153	0.225	0.051	-0.594	0.289	-0.678	0.498	18.84
Hubell 2004	-1.274	0.316	0.100	-1.892	-0.655	-4.037	0.000	9.59
	-0.441	0.098	0.010	-0.632	-0.249	-4.512	0.000	

Figure 10: The pooled estimated for all studies from 1995 through 2004 demonstrated significant differences (p=0.001) for eternal rotation deficits and the results favoured arthroscopic surgery.


Meta-Analysis: External Rotation Deficits for all included studies from 2005 until 2015

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Sperling 2005	-2.000	0.741	0.548	-3.452	-0.548	-2.701	0.007	2.41
Bottoni 2006	-0.812	0.267	0.071	-1.335	-0.289	-3.045	0.002	18.55
Rhee 2006	-0.211	0.307	0.094	-0.812	0.391	-0.687	0.492	14.01
Mahirogullari 2010	0.481	0.254	0.065	-0.017	0.979	1.894	0.058	20.44
Netto 2012	1.897	0.172	0.030	1.560	2.235	11.030	0.000	44.59
	0.716	0.115	0.013	0.491	0.941	6.234	0.000	

Figure 11: The pooled estimated for all studies from 2005 through 2015 demonstrated significant differences (p=0.0001) for eternal rotation deficits and the results favoured arthroscopic surgery. However the mean difference of 0.4 degrees between groups is almost certainly clinically irrelevant.

1995 through 2004 there were significant differences for recurrence rates between open and arthroscopic surgery, and for patients treated arthroscopically during this interval the risk of recurrence was double.

These results are somewhat surprising, as technological advances in arthroscopic surgery should have resulted in clinically meaningful and statistically significant improvements in functional outcomes and recurrence rates. Arthroscopic techniques have evolved from the Caspari technique using transglenoid sutures or arthroscopic tacks, to contemporary use of suture anchors [15,17] . Several authors have suggested that trans-glenoid sutures and tacks had a significantly higher failure rate compared to suture anchor repair [17,23,32,37] . The studies included in our analysis for the first decade from 1995 through 2004 almost exclusively used transglenoid techniques or tacks, and only one study [45] during the second decade utilized the Caspari technique. The remaining studies, in the decade from 2005 through 2015, have all used contemporary suture anchors.

Obviously, other factors are also responsible for the lack of reduction of recurrence rates for arthroscopic techniques between these two decades. Possibly the unexplained heterogeneity and poor quality of the included studies are partially responsible for these findings. Furthermore, given the heterogeneity of patient populations treated, differences in surgical skill and experience may have also contributed to these findings. The obvious advantage of arthroscopic surgery is the ability to treat additional intra-articular pathology with lower surgical morbidity, improved cosmesis, and decreased pain, without compromising surgical outcomes [15] . In a systematic review Harris et al. [15] could not demonstrate significant differences in recurrence rates between open (8%) and arthroscopic techniques (11%), even when use of tacks and Caspari techniques were included. When comparing arthroscopic suture anchor repair with open Bankart repair, no differences in recurrence rates were observed (8.5% versus 8%). Harris, et al. excluded studies reporting positive apprehension and subluxations, and only included recurrent dislocations as an absolutely quantifiable variable [15] . Similar to Harris, et al. we have also defined recurrence as a true dislocation. Studies that reported subluxations and positive apprehensions were included only if they also reported on recurrent dislocations, but this data was not analysed. Brophy, et al. investigated operative and non-operative treatment of traumatic anterior shoulder dislocation, and demonstrated a clear advantage for early surgical stabilization. However, they could not demonstrate any difference between open and arthroscopic surgery with regards to recurrence [4] . Not all patients required surgery [4,18,36] , and that may have skewed the results in favour of arthroscopic surgery, particularly if treatment was selected by the surgeon. Between 2004 and 2009 open Bankart repair declined from 4.48 per 10,000 patients to 2.24 per 10,000 patients, while arthroscopic repair increased from 0.17 per 10,000 patients to 0.4 per 10,000 patients [46] .

It is not quite clear why this meta-analysis has found significant differences between open and arthroscopic shoulder surgery within the first decade, yet failed to demonstrate significant differences for the second decade. One plausible explanation is that the between groups difference in failure rate of 6.1% in the first decade (16.8% in the arthroscopic group and 10.7% in the open group) resulted in statistical significance, while the 3.4% between groups difference in the second decade did not cause significance. Given that the recurrence rate for arthroscopic surgery did not decrease between the two decades investigated, the findings are possibly insignificant and are most likely clinically irrelevant.

Meta-analysis uses quantitative methods and statistics to investigate measures of central tendencies, and is currently considered to be the highest level of evidence [5]. With the inclusion of lower level studies, the level of evidence is adjusted to the level of the included studies. Practice recommendations from the studies included here indicates that clinicians should be flexible in their decision-making regarding appropriate practice. The GRADE assessment of the included studies reveals that all of the studies were of low quality. The current analysis included only four level one and seven level two studies, which constitute only 50% of the included studies. All included level one and two studies were downgraded because of the presence of selection bias (inappropriate proper randomization protocols or no randomization), detection bias (lack of blinding), attrition bias (incomplete or doubtful completion of data collection), performance bias (heterogeneity of surgical techniques), and transfer bias (patients lost to follow-up and different length of follow-up). As outlined by Harris, et al. [15], inclusion of retrospective studies with either case-control or comparative design, and the poor quality level one and two studies, are suboptimal to assess whether true differences exist. Future high quality prospective randomized studies are required, and may change the trend in either direction.

Given these inadequacies, the implications for clinical practice remain uncertain. The results of this meta-analysis certainly suggest that either open or arthroscopic surgical techniques can produce reliable and reproducible results with satisfactory outcomes, and recurrence rates between 10-15%. Advances in surgical techniques over the last

20 years using modern arthroscopic techniques with contemporary suture anchors do not appear to have resulted in any benefits over the more “historical” Caspari or Morgan techniques, or any other surgical methods utilizing tacks. The recurrence rates between the two decades only decreased marginally, by 2.5%. Harris, et al. performed a systematic review of long-term outcomes after Bankart shoulder stabilization, and could not demonstrate major differences between different implants with arthroscopic techniques [15] . However, it must be stressed again that the low quality and heterogeneity of the published literature on this topic makes it difficult to draw any valid binding conclusions.

The apparent benefits of arthroscopic surgery may therefore be based on subjective perceptions by both surgeons and patients. Of the 22 studies analysed, only four reported on return to physical activities. The mean return to physical activity was 48% in the arthroscopic group, and 60% in the open group. It is quite possible that the remaining patients decreased their activity level accordingly, to avoid further episodes of subluxation or apprehension.

The limitations of this meta-analysis are directly related to the limitations of the included studies. The moderate quality of the selected studies and their inherent biases, as well as the intra- and inter study heterogeneity, has substantially decreased the external validity of both the included studies and this meta-analysis. Therefore, these results should be interpreted with caution.

Conclusions

The results of this systematic review and meta-analysis suggest that despite advances in surgical techniques and devices over the last 20 years, either open or arthroscopic surgical treatment of anterior shoulder dislocation results in similar clinical outcomes and external rotation deficits. Even as arthroscopic techniques have evolved, the recurrence rate for arthroscopic surgical stabilisation has only marginally decreased from 16.8% to 14.2%. However, during the earlier decade from 1995 through 2004 patients treated with arthroscopic surgery had twice the risk of recurrence compared to an open procedure.

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