What is the most optimal bearing surface for minimizing instability after revision total hip arthroplasty?

Saad Tarabichi MD, Marije C. Vink MD, Rinne M. Peters MD, Mohamed Elkabbani MD, Jens T. Verhey MD, Ahmed H. Abdelazeem MD, Tim Petheram MD, Pieralberto Valpiana MD, Koos Jordaan MD, Sulaiman Alazzawi MD, Liu Xian-Zhe MD, Joshua S. Bingham MD, Wierd P. Zijlstra MD, PhD

Recommendation: Based on the results of our metanalysis, dual mobility implants appear to have the most efficacy in preventing the risk of instability in patients undergoing revision THA, when compared to those that received large femoral heads and constrained liners.

Strength of Recommendation: Moderate.

Rationale:

Instability remains one of the leading causes of failure following primary and revision total hip arthroplasty (THA) [1]. In recent years, several new implants have been developed in an attempt to mitigate the risk of instability and dislocation after surgery. In 2005, Berry et al. found that by increasing the jump distance, large femoral heads (LFH) (≥ 36 mm) were associated with a significant reduction in the risk of dislocation in patients undergoing primary THA [2]. Similarly, the use of constrained liners (CL) has also been shown to be an effective method for reducing the risk of instability in this patient population [3]. Most recently, dual mobility (DM) cups have gained traction following promising reports in the literature [4]. In a study of the

American Joint Replacement Registry, the utilization of DM implants in patients undergoing revision THA was found to have increased from 19.5% in 2012 to 30.6% in 2018 [5]. Notwithstanding, the optimal bearing surface for minimizing instability after revision THA remains a contentious issue.

A systematic review and meta-analysis was performed using the following databases: Embase, Pubmed, Cochrane, Google Scolar, and Web of Science. The primary outcomes of our study were the rate of dislocation and reoperation for dislocation. Secondary outcomes included complications, functional outcomes scores, and revision surgery for any reason. Our inclusion criteria consisted of studies that included patients that were ≥ 18 years undergoing revision THA with the use of either a DM cup, LFH (≥ 36 mm), or CL. We only included studies that addressed our primary and/or secondary outcomes measures, had >50 patients, included a comparison group, and were published within the last 10 years. All studies were screened by three independent reviewers and assessed on methodological quality. Any disagreements were settled in a consensus meeting that involved a fourth reviewer.

1,510 records were identified using our search strategy. After screening, 55 studies were considered eligible for full text review. A total of 14 studies were included in the final analysis [6–19]. DM implants (odds ratio [OR] 0.34 [95% CI 0.20 to 0.60]; p<0.001) were associated with a significant reduction in the risk of dislocation when compared to LFH. Similarly, DM implants (OR, 0.36 [95% CI 0.21 to 0.62]; p<0.001) were also found to be protective against dislocation when compared to CL. However, there was no difference in the dislocation rate between patients that received LFH and those that received CL (p=0.56) (Figure 1; Figure 2 appendix). Although DM implants had a higher risk of revision surgery secondary to dislocation, when compared to LFH (OR 1.35 [95% CI 1.13 to 1.61]; p<.001), there was significant heterogeneity amongst the studies included in this sub analysis ($I^2 \geq 50\%$). On the other hand, CL was not associated with an increased risk of revision surgery due to dislocation, when compared to DM and LFH (Figure 3, appendix). Additionally, there was also no association between bearing type and the risk of revision surgery for any reason, when comparing between DM, LFH, and CL implants. Of note, one study reported patient reported outcome scores and found no difference in Harris Hip Score (HHS) between patients that received DM, LFH, and CL.

Based on the results of our metanalysis, DM implants appear to have the most efficacy in preventing instability following revision THA. Notwithstanding, given the relatively small sample sizes of the included studies, in conjunction with heterogeneity in study design, it is important to recognize that further large randomized controlled trials are necessary in order to determine the optimal bearing surface to reduce the risk of instability after revision THA.

Figure 1. Risk of Dislocation in Large Femoral Heads, when compared to Dual Mobility Implants

	DMC		LFH			Odds Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**
Hartzler 2018	4	126	17	176	23,5%	0,31 [0,10, 0,93]
Hermansen 2020	5	140	129	1054	49,8%	0,27 [0,11, 0,66]
McAlister 2019	1	35	24	267	9,2%	0,30 [0,04, 2,27]
Stevenson 2020	4	48	12	99	12,3%	0,66 [0,20, 2,16]
Weintraub 2022	2	76	3	70	5,2%	0,60 [0,10, 3,72]
Total (95% CI)		**425**		**1666**	**100,0%**	**0,34 [0,20, 0,60]**
Total events	16		185			

Heterogeneity: Chi² = 1,89, df = 4 (P = 0,76); I² = 0%
Test for overall effect: Z = 3,81 (P = 0,0001)

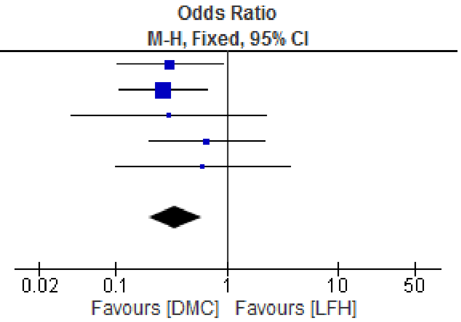
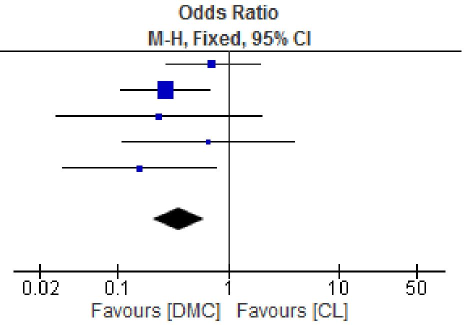


Figure 2. Risk of Dislocation in Constrained Liners, when compared to Dual Mobility Implants

	DMC		CL			Odds Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**
Chisari 2021	14	139	7	52	18,7%	0,72 [0,27, 1,90]
Hermansen 2020	5	140	69	572	53,5%	0,27 [0,11, 0,68]
McAlister 2019	1	35	7	63	9,9%	0,24 [0,03, 2,00]
Scholz 2024	6	38	2	9	5,6%	0,66 [0,11, 3,96]
Stevenson 2020	4	48	4	11	12,2%	0,16 [0,03, 0,79]
Total (95% CI)		**400**		**707**	**100,0%**	**0,36 [0,21, 0,62]**
Total events	30		89			

Heterogeneity: Chi² = 3,92, df = 4 (P = 0,42); I² = 0%
Test for overall effect: Z = 3,67 (P = 0,0002)



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Appendix

1. **Search strategy**

OVID Medline (416 results)
((revision* OR revised) ADJ3 (hip arthroplast* OR hip replacement* OR hip total arthroplast* OR hip total joint replacement* OR hip total replacement* OR THA) AND ((constrain* adj3 (liner* OR cup* OR device* OR implant* OR component* OR bearing* OR socket* OR construct* OR insert* OR THA OR arthroplast*)) OR ((big OR bigger OR large) adj3 (head* OR bearing*)) OR 36mm OR 36 mm OR 40mm OR 40 mm OR 42mm OR 42 mm OR 44mm OR 44 mm OR dual mobility OR double mobility OR mobile bearing OR dualmobility OR doublemobility OR mobilebearing OR DMC)).ti,ab,kw.

EMBASE (484 results)
(((revision* OR revised) NEAR/3 ("hip arthroplast*" OR "hip replacement*" OR "hip total arthroplast*" OR "hip total joint replacement*" OR "hip total replacement*" OR THA)):ti,ab,kw) AND ('dual mobility cup'/exp OR 'dual mobility liner'/exp OR ("dual mobility" OR "double mobility" OR "mobile bearing" OR "dualmobility" OR "doublemobility" OR "mobilebearing" OR DMC OR 36mm OR "36 mm" OR 40mm OR "40 mm" OR 42mm OR "42 mm" OR 44mm OR "44 mm" OR ((big OR bigger OR large) NEAR/3 (head* OR bearing*)) OR (constrain* NEAR/3 (liner* OR cup* OR device* OR implant* OR component* OR bearing* OR socket* OR construct* OR insert* OR THA OR arthroplast*))):ti,ab,kw)

Web of Science (394 resultaten)
(TS=((revision* OR revised) NEAR/3 ("hip arthroplast*" OR "hip replacement*" OR "hip total arthroplast*" OR "hip total joint replacement*" OR "hip total replacement*" OR THA))) AND (TS=(((big OR bigger OR large) NEAR/3 (head* OR bearing*)) OR 36mm OR "36 mm" OR 40mm OR "40 mm" OR 42mm OR "42 mm" OR 44mm OR "44 mm" OR "dual mobility" OR "double mobility" OR "mobile bearing" OR "dualmobility" OR "doublemobility" OR "mobilebearing" OR DMC OR (constrain* NEAR/3 (liner* OR cup* OR device* OR implant* OR component* OR bearing* OR socket* OR construct* OR insert* OR THA OR arthroplast*)))) AND DT=article

Cochrane (16 resultaten)

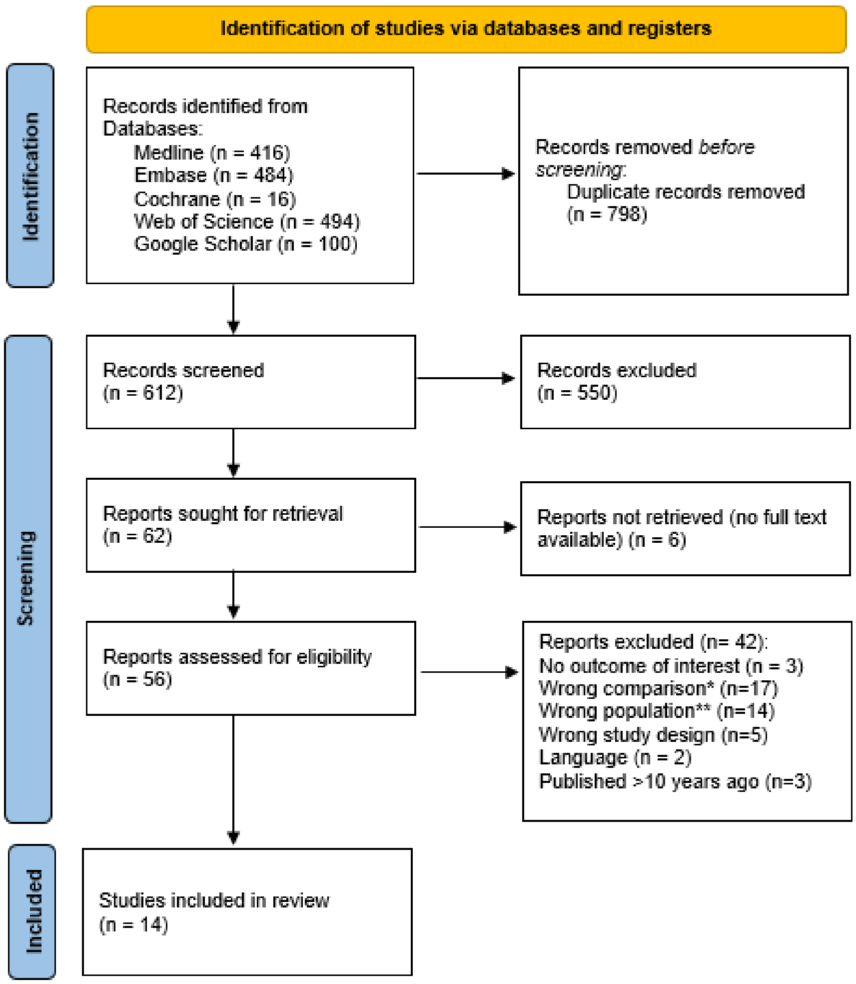
ID	Search	Hits
#1	((revision* OR revised) NEAR/3 ("hip arthroplasty" OR "hip replacement" OR "hip total arthroplasty" OR "hip total joint replacement" OR "hip total replacement" OR "hip arthroplasties" OR "hip replacements" OR "hip total arthroplasties" OR "hip total joint replacements" OR "hip total replacements" OR THA)):ti,ab,kw	142
#2	(((big OR bigger OR large) NEAR/3 (head* OR bearing*)) OR 36mm OR "36 mm" OR 40mm OR "40 mm" OR 42mm OR "42 mm" OR 44mm OR "44 mm"):ti,ab,kw	5406
#3	("dual mobility" OR "double mobility" OR "mobile bearing" OR "dualmobility" OR "doublemobility" OR "mobilebearing" OR DMC):ti,ab,kw	769
#4	(constrain* NEAR/3 (liner* OR cup* OR device* OR implant* OR component* OR bearing* OR socket* OR construct* OR insert* OR THA OR arthroplast*)):ti,ab,kw	56
#5	#2 OR #3 OR #4	6218
#6	#1 AND #5	16

https://www.cochranelibrary.com/advanced-search/search-manager?search=7455159

Google scholar (7290 results) > selected first 100 articles

"Revision total hip arthroplasty"|"revision hip arthroplasty"|"revision THA" "mobile bearing"|"dual mobility"|"double mobility"|"36 mm"|"40 mm"|"42 mm"|"44 mm"|"large head"|"large bearing"|constrained

2. Flowchart



*= No distinction in head sizes of standard bearings (unclear whether 36+ heads are analyzed or also <36mm), no comparison with CL/DM or SB, no large heads included in standard bearings

**=primary procedures, or less than 50 patients included in analysis.

3. Included studies

Table 1: Summary of included studies							
Author, Year Country	**Study Design**	**Comparison of:**	**Follow-up (range)**	**No. of patients per group (n)**	**Age, mean (y) and range**	**Sex (male/ female in %)**	**Outcome variables**
Chisari (2021) United States	Retrospective cohort study	DM vs CL	14.3 months	DMC: 139 CL: 52	63 (51-75)	42/58	1, 2, 4
Di Martino (2023) *Italy*	Retrospective cohort study, national registry (RIPO)	DMC vs LFH	Max 10 years	DMC: 57 LFH: 66	71 (DMC) 75 (SB)	34/66	2, 4
Hartzler (2017) United States	Retrospective cohort study	DM vs SB (LFH)	3.3± 0.8 years(DM) 3.9±0.9 years (LFH)	DMC: 126 LFH: 176	65 (SB) 66 (DM)	59/41 (SB) 48/52 (DM)	1, 2, 3, 4
Hermansen (2020) Denmark	Retrospective cohort study, national registry (DHAR)	DM vs LFH vs CL	5.3 (1 day – 21.6 years)	DMC: 140 LFH: 1,054 CL: 572	72	45/55	1,4
Hoskins (2020) Australia	Retrospective cohort study, national registry (AOANJRR)	DM vs LFH vs CL	4.81 ± 4.16	DMC: 265 LFH: 387 CL: 288	71 ± 10.8	37/63	2,4
Hoskins (2021) Australia	Retrospective cohort study, national registry (AOANJRR)	DMC vs LFH vs CL	1-10 years (mean/median not reported)	DMC: 104 LFH: 225 CL: 105	78 (36-79)	28/72	2, 4
Hoskins (2022) Australia	Retrospective cohort study, national registry (AOANJRR)	DM vs LFH	4 years [1.1-6.9] (LFH) 2 years [0.2-3.8] (DM)	DMC: 502 LFH: 793	65 [53-77] (SB) 67 [56-78] (DM)	49/51 (LFH) 33/67 (DM)	2, 4
Jo (2015) United States	Retrospective cohort study,	LFH vs CL	5.5 years (1 day – 17.4 y ears)	LFH: 46 CL: 241	66.1 (23-94)	40/60	1, 4

	institutional registry						
Klemt (2022) Germany	Retrospective cohort study, institutional registry	LFH vs CL	4.6 years (3.1-5)	LFH: 130 CL: 81	86.1 ± 13.3	35/65	2, 4
McAlister (2019) United States	Single centre retrospective cohort study	DMC vs LFH vs CL	5 years (2-15)	DMC: 35 LFH: 267 CL: 63	65.2 (19-91)	55/45	1
Otero (2023) United states	Retrospective cohort study, national registry (AJRR)	DMC vs LFH		DMC: 3,043 LFH: 11,120	51% between 64-74 years	40/60	2, 4
Scholz 2024 Germany	Single centre retrospective cohort study	DM vs CL	5.0 years (2.0-8.75)	DMC: 38 CL: 9	70 (43-88)	37/63	1, 2, 5
Stevenson (2020) United States	Retrospective cohort	DMC vs LFH vs CL	55.8 months (12.1-159)	DMC: 48 LFH: 99 CL: 11	61 (27-91)	39/61	1, 2, 4
Weintraub 2023	RCT	DM vs LFH	18.2 months (1.4-48.2)	DMC: 76 LFH: 70	68 [40-93] (LFH) 67 [43-90] (DM)	56/44 (LFH) 37/63 (DM)	1, 2, 4
1= Dislocation, 2=Re-revision for dislocation, 3=Complications, 4=Re-revision for any reason, 5=HHS/PROMs							

4. Quality assessment

Table 2. Newcastle Ottawa Quality Assessment for cohort studies

Studies	Selection				Comparability	Outcome			Total quality score
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure to implants	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts [a]	Assessment of outcome	Was follow up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Chisari 2021	★	★	★	★	★☆	★	☆	☆	6/9 Fair
Di Martino 2023	☆	★	★	★	☆☆	★	★	☆	5/9 Poor
Hartzler 2018	★	★	★	★	★☆	★	★	★	8/9 Good
Hermansen 2020	☆	☆	★	★	★☆	★	★	★	6/9 Fair
Hoskins 2020	☆	★	★	★	★☆	★	★	★	7/9 Good
Hoskins 2021	☆	★	★	★	★☆	★	★	★	7/9 Good
Hoskins 2022	★	★	★	★	★☆	★	★	★	8/9 Good
Jo 2015	★	★	★	★	★☆	★	★	☆	7/9 Good
Klemt 2022	☆	★	★	★	★☆	★	★	★	7/9 Good
McAlister 2019	☆	★	★	★	☆☆	★	★	★	6/9 Poor
Otero 2023	★	★	★	★	★☆	★	★	★	8/9 Good
Scholz 2024	☆	★	★	★	☆☆	★	★	★	6/9 Poor
Stevenson 2020	☆	★	★	★	★☆	★	★	★	7/9 Good

[a] Comparability of cohorts on the basis of the design or analysis: Marital status was not recorded in the included studies, therefore no study could be rewarded full score on comparability

Table 2.2 Risk of bias assessment for RCT	Weintraub (2022)	= Moderate risk of bias Reason:
Random sequence generation (selection bias)	Low risk	Randomization by random number generator by an indivicual who was not involved in data collection.
Allocation concealment (selection bias)	Low risk	Patients were blinded to their randomization prior to surgery
Blinding of participants and personnel (performance bias)	High risk	Surgeons could not be blinded. Duration hip precautions depended on preference surgeon.
Blinding of outcome assessment (detection bias)	Low risk	Outcome is objective (dislocation rate, revision rate etc)
Incomplete outcome data (attrition bias)	Low risk	No loss to follow up (n=0)
Selective reporting (reporting bias)	Low risk	
Other bias	High risk	Interim analysis, no full power yet achieved. Short follow up time. No standardized protocols between surgeons and study sites.

5. Meta-analysis

Figure 2.1 Dislocation risk DMC vs LFH

Study or Subgroup	DMC Events	DMC Total	LFH Events	LFH Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Hartzler 2018	4	126	17	176	23,5%	0,31 [0,10, 0,93]
Hermansen 2020	5	140	129	1054	49,8%	0,27 [0,11, 0,66]
McAlister 2019	1	35	24	267	9,2%	0,30 [0,04, 2,27]
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Total (95% CI)		**425**		**1666**	**100,0%**	**0,34 [0,20, 0,60]**
Total events	16		185			

Heterogeneity: Chi² = 1,89, df = 4 (P = 0,76); I² = 0%
Test for overall effect: Z = 3,81 (P = 0,0001)

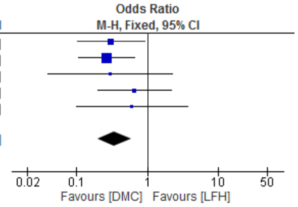

Figure 2.2 Dislocation risk DMC vs CL

Study or Subgroup	DMC Events	DMC Total	CL Events	CL Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Chisari 2021	14	139	7	52	18,7%	0,72 [0,27, 1,90]
Hermansen 2020	5	140	69	572	53,5%	0,27 [0,11, 0,68]
McAlister 2019	1	35	7	63	9,9%	0,24 [0,03, 2,00]
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Total (95% CI)		**400**		**707**	**100,0%**	**0,36 [0,21, 0,62]**
Total events	30		89			

Heterogeneity: Chi² = 3,92, df = 4 (P = 0,42); I² = 0%
Test for overall effect: Z = 3,67 (P = 0,0002)

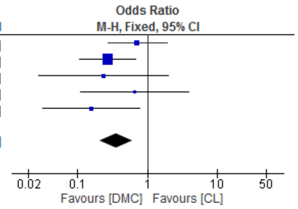

Figure 2.3 Dislocation risk of LFH vs CL

Study or Subgroup	LFH Events	LFH Total	CL Events	CL Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Hermansen 2020	129	1054	69	572	74,9%	1,02 [0,74, 1,39]
Jo 2015	5	46	34	241	9,3%	0,74 [0,27, 2,01]
McAlister 2019	24	267	7	63	9,8%	0,79 [0,32, 1,93]
Stevenson 2020	12	99	4	11	6,0%	0,24 [0,06, 0,95]
Total (95% CI)		**1466**		**887**	**100,0%**	**0,92 [0,70, 1,21]**
Total events	170		114			

Heterogeneity: Chi² = 4,36, df = 3 (P = 0,23); I² = 31%
Test for overall effect: Z = 0,58 (P = 0,56)

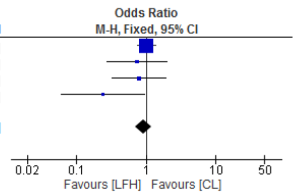

Figure 3.1 Re-revision due to dislocation, DMC vs LFH

Study or Subgroup	DMC Events	DMC Total	LFH Events	LFH Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Di Martino 2023	0	57	2	66	1,2%	0,22 [0,01, 4,77]
Hartzler 2018	1	126	10	176	4,2%	0,13 [0,02, 1,05]
Hoskins 2020	11	265	24	387	9,5%	0,66 [0,32, 1,36]
Hoskins 2021	2	104	4	225	1,3%	1,08 [0,20, 6,01]
Hoskins 2022	15	502	27	793	10,3%	0,87 [0,46, 1,66]
Otero 2023	148	3043	336	11120	69,7%	1,64 [1,35, 2,00]
Stevenson 2020	4	48	11	99	3,3%	0,73 [0,22, 2,42]
Weintraub 2022	2	76	1	70	0,5%	1,86 [0,17, 21,03]
Total (95% CI)		**4221**		**12936**	**100,0%**	**1,35 [1,13, 1,61]**
Total events	183		415			

Heterogeneity: Chi² = 16,55, df = 7 (P = 0,02); I² = 58%
Test for overall effect: Z = 3,33 (P = 0,0009)

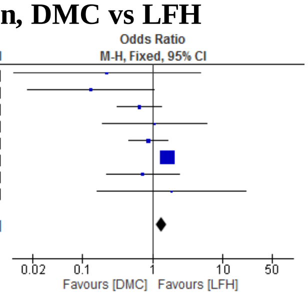

Figure 3.2 Re-revision due to dislocation, DMC vs CL

Study or Subgroup	DMC Events	DMC Total	CL Events	CL Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Hoskins 2020	11	265	13	288	49,3%	0,92 [0,40, 2,08]
Hoskins 2021	2	104	2	105	8,1%	1,01 [0,14, 7,31]
Scholz 2024	4	38	2	9	11,9%	0,41 [0,06, 2,70]
Stevenson 2020	4	48	5	11	30,8%	0,11 [0,02, 0,52]
Total (95% CI)		**455**		**413**	**100,0%**	**0,62 [0,33, 1,16]**
Total events	21		22			

Heterogeneity: Chi² = 6,00, df = 3 (P = 0,11); I² = 50%
Test for overall effect: Z = 1,50 (P = 0,13)

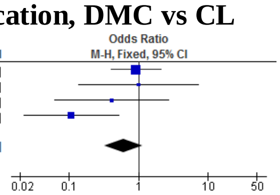

Figure 3.3 Re-revision due to dislocation, LFH vs CL

Study or Subgroup	LFH Events	LFH Total	CL Events	CL Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Hoskins 2020	24	387	13	288	51,9%	1,40 [0,70, 2,80]
Hoskins 2021	4	225	2	105	9,9%	0,93 [0,17, 5,17]
Klemt 2022	9	130	2	81	8,5%	2,94 [0,62, 13,96]
Stevenson 2020	11	99	5	11	29,7%	0,15 [0,04, 0,57]
Total (95% CI)		**841**		**485**	**100,0%**	**1,11 [0,66, 1,88]**
Total events	48		22			

Heterogeneity: Chi² = 10,51, df = 3 (P = 0,01); I² = 71%
Test for overall effect: Z = 0,40 (P = 0,69)