

Higher risk of revision in total knee arthroplasty after high tibial osteotomy: A systematic review and updated meta-analysis

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Abstract

Background: High tibial osteotomy is commonly performed in young patients with high activity demand. It is reported up to 30% of HTO need subsequent conversion to TKA. Primary TKA now provides satisfactory long-term outcome in terms of function and survival. Researches have been conducted to compare clinical outcome between primary TKA and TKA after HTO to see if primary should be the prior treatment rather than HTO in some cases. But the results were inconsistent. This study aims to compare the risk of revision and other parameters of total knee arthroplasty after high tibial osteotomy and primary total knee arthroplasty.

Methods: Thorough searches and screens of the relevant literature were conducted, after which data were extracted and pooled analysis was performed to compare the clinical outcomes between the two groups.

Results: A total of 14 studies with 144,692 cases were included. Pooled analysis showed significantly more revisions and complications and more tibial component loosening and impingement in postoperative X-ray in the HTO-TKA group. Surgical complexity during conversion to total knee arthroplasty was summarised and listed in a table.

Conclusion: Total knee arthroplasty after tibial osteotomy is a technically challenging procedure and provide inferior clinical outcomes than primary TKA. Given the success of primary TKA, it may be considered as the first choice in young patients with high activity demand.

Introduction

High tibial osteotomy (HTO) is a well-established procedure for uni-compartmental osteoarthritis of the knee and is commonly applied to young patients with high activity demands. There has been an increasing interest in high tibial osteotomy in some countries over the past decade[1]. The goal of this operation lies in correction of the mechanical axis of the lower limb, reducing the load stress of the pathological medial compartment. HTO has been reported to achieve satisfactory short-term clinical result, many of them regain satisfactory functional outcome. However, most patients who undergo this operation are relatively young, with high activity demand; research has reported that up to 30% of these patients require subsequent TKA[2, 3]. These conversions to TKA are more technically demanding than primary TKA and may lead to inferior survival and functional outcomes compared to primary TKA. Researches have been conducted to compare risk of revision and functional outcome between primary TKA and TKA after HTO, which have reported controversial results. Some studies found HTO-TKA is at higher risk of revision and complication[4–6], while other studies reported similar outcome in both groups[2, 7–9].

A previous meta-analysis published in 2013 reported similar outcomes between TKA following HTO and primary TKA in terms of survival and perioperative complications[10]. Most studies included in the previous meta-analysis investigated cohorts of small sample size. Several studies with larger cohorts have been published since then, some of which reported inferior survival and clinical outcomes in cases

underwent TKA after HTO[2, 4, 7, 11]. Therefore, an updated meta-analysis and systematic review was conducted to compare risk of revision and other clinical parameters between TKA after HTO and primary TKA.

Material And Methods

Search strategy

MEDLINE, Embase and the Cochrane Library were thoroughly searched by two independent researchers in April 2018. Search terms included tibial osteotomy, knee, replacement, arthroplasty and related MeSH terms.

Inclusion and exclusion criteria

Studies were included if they (1) included patients undergoing TKA following HTO and patients undergoing primary TKA; (2) compared risk of revision between HTO after TKA and primary TKA(providing exact number of cases of primary TKAs, revision of primary TKAs, TKAs after HTO, Revision in TKAs after HTO); Studies were excluded if they (1) did not report quantitative data; (2) were a conference abstract, animal studies, cadaveric studies or in vitro studies.

Data extraction and quality assessment

Data were collected and reviewed by two independent researchers. The quality of included studies was evaluated according to the Newcastle-Ottawa Scale (NOS).

Statistical analysis

Data of interest were extracted and analysed using Review Manager 5.2 and STATA 14 as the forest plot produced by Review Manager offers more detailed information and STATA provides more options for heterogeneity assessment. All data and analysis were cross-examined. Peto's method was utilized if incidence is considered rare; other discontinuous variables were analysed by odds ratios (ORs). Continuous data with mean and SD were analysed by weighted mean differences (WMDs). Heterogeneity among studies was assessed using the χ^2 test, I^2 and L'abbe test. Generally, a fixed-effects model was applied when $I^2 < 50\%$, and a random-effects model when $I^2 > 50\%$. A p value < 0.05 was considered statistically significant. If the analysis was conducted with Peto's method, a fixed effect model was applied. When trials had no event in one arm or another, a small quantity (0.5) of the cell counts would be added to avoid division by zero errors as suggested in the Systematic Reviews in Health Care: Meta-

Analysis in Context. It is also suggested when the count is zero in both arms, and the risk difference is zero. Publication bias is evaluated by funnel plot if needed.

Results

Study characteristics

A total of 15 studies were included in our analysis after a comprehensive search and screening (Figure 1), the basic characteristics of which are listed in Table 1. All studies compared the clinical outcomes between TKA following HTO (HTO-TKA) and primary TKA. Quality assessment was conducted by two independent researchers according to the NOS quality score. All included studies yielded moderate quality, with an average score of 6 (ranging from 5 to 8).

Most included studies had a minimum follow-up of 1 years (ranging from 1 to 14 years) except 3 registry based studies which did not specify follow-up time[4, 6, 7]; 4646 cases of TKA following HTO and 140,074 cases of primary TKA were included in our study. Parameters, including revision, complication, radiographic outcome and functional outcome were analysed. It was found in our initial screening process that two studies reported on the same cohort; requisite information was gathered and the study with quantitative data of revision cases after primary TKA and with the latest follow-up was included[8, 12]. Four studies[2, 4, 6, 7], which included 3391 cases of TKA following HTO and 133,352 cases of primary TKA, were registry-based studies that reported the survival and complications of the 2 groups. In 5 studies[5, 8, 13–15], all cases from the HTO-TKA group underwent lateral closing wedge osteotomy, whereas 1 study[9] reported 42 lateral closing wedge osteotomies and 8 dome osteotomies performed. Two studies[16, 17] included only cases with opening wedge osteotomy, and the remaining 7 studies[2, 4, 6, 7, 18, 19] did not specify which technique was applied.

Revision

Revision was defined as removal, exchange, insertion of any component or any changes made to an existing component in an existing arthroplasty. After extracting data from all 14 studies, it was found that 356 of 4646(7.66%) cases from the HTO-TKA group and 5315 of 140,074(3.79%) cases from the primary TKA group were revised. Pooled analysis showed significantly more revisions in the HTO-TKA group when analysing with (OR 2.09, 95% CI: 1.81–2.41, $P <0.0001$, $I^2 = 84\%$) (Figure 2). The difference is still statistically significant when only cases undergoing lateral closing wedge osteotomy were included (OR 4.07, 95% CI: 1.64–10.11, $P <0.003$, $I^2 = 8\%$)[5, 8, 13, 14]. The average interval between HTO and subsequent TKA ranges from 4.7 to 8.7 years(Table 2). The average follow-up period ranged from 1 to 8 years, except for 3 registry based studies[4, 6, 7] which did not specify follow-up time(Table 2). 7 included studies reported revision rate between 9 to 16%, 4 studies reported no cases of revision in HTO-TKA group, 1 study reported 21.6% of the HTO-TKA cases underwent revision, 3 studies reported revision rate between 2.5% to 5.9%(Table 2). Eight studies reported reasons for revision in both groups, aseptic

loosening(16.78% in HTO-TKA, 22.39% in primary TKA) and deep infection(22.70% in HTO-TKA, 26.54% in primary TKA) were major reasons for revision in both groups, while. Pooled analysis showed no significant difference in terms of reasons for revisions between both groups.

Surgical complexity and solution

Some studies reported prolonged surgical time in the HTO-TKA group; pooled analysis was unattainable because most studies reported only the average surgical time without standard deviation[4, 7, 9, 14, 16, 19]. Perioperative blood loss was also higher, as reported in 2 studies[13, 19]. Seven of the included studies[6, 7, 9, 13, 15–17] reported solutions to surgical complexity in the HTO-TKA group; these are listed in Table 3. Three hundred thirty-four of 1422 (23.5%) cases included a required stemmed implant. Difficulty during exposure and balancing were also noted in some studies[4, 9, 13, 17].

Radiographic outcome

Several studies[5, 16, 18] compared radiographic outcome between the 2 groups. The HTO-TKA group showed significantly more tibial component loosening and impingement than the primary TKA group did. No differences were found between groups in terms of femoral component (α), tibial component (β), femoral component flexion (γ) and loosening of the femoral component (Table4).

Publication bias

Funnel plot(Figure3) was conducted in the analysis of total revision, which showed that most studies were within 95% CIs, leaving 2 studies on the edge and 2 studies outside the edge. Slight asymmetry was also noted in the funnel plot.L'abbe test(Figure4) was then conducted to assess heterogeneity among different studies in terms of local recurrence, which showed low heterogeneity among included studies.

Sensitivity analysis

Sensitivity analysis was conducted by excluding studies with fewer than 50 cases included[14, 15] which did not show a significant impact on the results.

Discussion

High tibial osteotomy was introduced in 1969 by Jackson and Waugh and has become a well-established procedure for unicompartmental knee osteoarthritis since then. The biomechanical rationale for this procedure is correction of malalignment and redistribution of stress on the joint[20].

The classic indication for high tibial osteotomy includes unicompartmental osteoarthritis of the knee and is especially recommended for young patients with high activity demands[21, 22]. For properly selected patients, studies have proven that it offers satisfactory pain relief and functional outcome. However, clinical improvement wears out over time and the majority of patients who underwent this procedure were relatively young. Previous researches have reported subsequent TKAs were required in up to 30% of these cases[3]. Concerns were raised that whether these HTO-TKA would provide comparable survival comparing to primary TKA. There have been conflicting reports regarding this issue. A previous meta-analysis, consisting of 11 studies with 421 HTO-TKAs and 1749 primary TKAs found no significant differences in terms of revision, complications and functional outcome[10]. In our analysis, 15 studies with 4646 HTO-TKAs and 140074 primary TKAs were included, the substantial increase of sample size may help to investigate low-incidence event such as revision. Pooled-analysis showed significantly more revisions in the HTO-TKA group, though majority of studies included in our analysis reported comparable survival between the two groups. The increased surgical difficulties during the conversion from HTO to TKA might be one contributing factor to our finding, Robertsson[23] et al reported more stemmed implants were required during the conversion from HTO to TKA. In our analysis, aseptic loosening was the leading cause for revision in the HTO-TKA group, followed by deep infection, which is similar to that of primary TKA[24]. Other main causes included malalignment and persistent pain. Low patella, which might be presented as anterior knee pain, was once considered a major cause for the elevated revision rate in the HTO-TKA group and was subjected to surgical technique[18]. In our series, based on available data, 10 out of the 304 revised TKA after HTO were patella-related. Pooled analysis, excluding patella-related revision also showed consistent results in favour of primary TKA. Patella arthroplasty might prevent future anterior knee pain and patella-related revision. More revisions due to instability were noted by El-Galaly et al.[4], attributing it to altered anatomy in the conversion. The prior osteotomy complicated the anatomical structure of the knee, resulting in varying degrees of deformity, remaining hardware, bone loss and soft-tissue imbalance.

Different osteotomy techniques might influence the risk for subsequent TKA; our analysis showed that prior lateral closing wedge osteotomy also led to significantly more revisions in subsequent revisions. Amendola et al.[18] argued that the time in which the subsequent TKA was performed was also crucial and that surgeons tend to have a better understanding of the technical difficulties to achieve comparable results over time. In our series, four studies were published within the last 5 years; three[4, 7] of them suggested similar survival between 2 groups, whereas one study[2] reported survival in favour of primary TKA. Pooled analysis from these 4 studies still showed significantly more revision in the HTO-TKA group.

Several methods, including lateral release of the lateral alar ligament of the patella; quadriceps snips; even osteotomy of the anterior tibial tuberosity were suggested in order to tackle the technical difficulties encountered during the conversion to TKA due to the presence of scarring tissue which poses substantial challenge during exposure[25–28]. In our series, rectus snips remain the most common technique to achieve satisfactory exposure. Amendola et al[18]. verified that in cases with prior osteotomy, the medial plateau is higher than the lateral plateau in anteroposterior (AP) radiographs. Erak et al[18]. reported preoperative patella baja relating to difficulty with patella eversion. In order to balance the knee, release of

lateral ligament was also suggested due to the extra medial dissection to remove osteotomy hardware[18]. The bone resected in the lateral region must be minimal to avoid a large defect. Wedges were used in 4 out of 711 cases as reported by Pearse[6] in our series. A high percentage of stemmed implants were used in the HTO-TKA group; this may result from the need to avoid a potential stress riser. Ligament balancing is crucial in cases with prior osteotomy; the fibrosis and loss of soft tissue may lead to instability[28]. The most common balancing technique in our analysis was lateral release(31/125). Difficulty during exposure, resection and component positioning contributed to the prolonged surgical time and led to increased blood loss.

Few studies reported on radiographic outcome between the two groups. Based on available data, more loosening of the tibial component and impingement were noted in the HTO-TKA group, which correlates with our analysis of revision. No significant differences were found in terms of alignment. Kazakos et al. [13] reported 16 cases of patella baja in the HTO-TKA group, with only two in the control group. Other studies also stated patella baja to be more common after HTO, but they did not find any relevance between patella baja and the clinical outcome of subsequent TKA[27, 29].

Our study has several limitations. (1) All included studies were retrospective studies and registry based studies whereas no RCT was included, which limited the quality of this meta-analysis. (2) The mean follow-up was not consistent among studies; revisions might not be required until 10–20 years later. (3) Some studies only reported mean and range for parameters such as surgical time, blood loss and functional score, and we were unable to conduct pooled analysis based on these data. (5) Some causes of revision were marked as unknown in some studies, which influenced our analysis of the causes of revision.

The strengths of this meta-analysis include the following. (1) This study focused on risk of revisions and further investigate surgical complexity and radiographic outcomes with more cases involved and explored potential causes for the differences between groups. Most studies reported comparable survival outcome between the two groups, whereas pooled analysis of gathered data revealed statistically significant results. (2) Due to the lack of relevant studies and cohort, this meta-analysis gathers valuable information to conduct a quantitative analysis and yielded result inconsistent with the first meta-analysis on this subject. (3) Randomised trials were not feasible considering our research purpose; this study gathers data from retrospective studies and provides the best evidence available. (4) Relevant articles were screened carefully by two independent researchers, using a wide range of search terms. (5) Previous meta-analysis on this subject included 421 HTO-TKAs and 1749 primary TKAs, while our study included 4646 HTO-TKAs and 140074 primary TKAs, the increased sample size allow us to assess small-incidence event such as revision with more accuracy. (6) Considering the wide variation of publishing time of included studies, pooled analysis of studies published within the last five 5 years yielded consistent finding. (7) Clear inclusion and exclusion criteria were utilized.

Conclusion

High tibial osteotomy offers satisfactory pain relief and functional outcome in selected patients with high activity demand. However, the need for subsequent TKA should be noted, which might be a technically challenging procedure with significantly higher risk of revision comparing to primary TKA.

Declaration

All authors declare no conflict of interest. Since our study is a meta-analysis, an Ethical Review Committee Statement is not required.

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Tables

Table 1. Study Characteristics

	HTO-TKA		TKA		Country	Matching	NOS Scale
	Patients	Cases	Patients	Cases			
Amendola 2010	24	29	28	29	Italy	1,4,5	*****
Bergenudd 1997	14	19	99	111	Sweden	NS	****
Efe 2010	41	41	41	41	Germany	1,2,6,7	*****
Erak 2011	33	34		1315	Canada	6,8	*****
Haddad 2000	42	50	42	50	UK	1,2,3	*****
Haslam 2007	40	51	44	51	UK	1,2,7,9	*****
Karabatsos 2002	20	22	20	21	Canada	1,2	*****
Kazakos 2008	32	38	32	38	Greece	1,2,3,5	*****
Meding 2011	39	39	39	39	USA	NS	*****
Van 2007	12	14	12	14	Netherland	1,2,7,8	*****
Pearse 2012	711		34369		New Zealand	NS	****
DAHL 2016	119		5013		Sweden	NS	****
Badawy 2015	1399		31077		Bergen	NS	****
Niinimaki 2014	1036		4143		Finland	1,2	*****
El-Galaly 2018	1044		63763		Denmark	NS	****
1.age 2.sex 3.weight 4.alignment 5.functional score 6.follow-up 7.prosthesis 8.BMI 9.surgeon							

Table 2. Revisions in HTO-TKA group

Revision in HTO-TKA group

	Amendola	BADAWY	Bergenudd	Efe	El-Galaly	Erak	Haddad	Haslam
Revision Cases	4/29	83/1399	3/19	4/41	98/1044	0/34	6/50	11/51
Revision Rate	13.8%	5.9%	15.8%	9.8%	9.4%	0	12%	21.6%
Average Follow-up yrs.	8(3-13)	NS	6(4-9)	7(4-10)	NS	3.4(2-8)	6.2(5-10)	>5
Average interval yrs.	8.39	NS	NS	7.16	NS	4.7	7.3	4.8
	Karabatsos	Kazakos	Meding	Niinimaki	Pears	W-DAHL	Van	
Revision Cases	0/22	0/38	6/39	93/1036	45/711	3/119	0/14	
Revision Rate	0	0	15.4%	9.0%	6.3%	2.5%	0	
Average Follow-up yrs.	5.2	4.5(3-8)	14	>1	NS	>3	>2	
Average interval yrs.	8.4	7.3	8.7	NS	NS	NS	NS	

Table 3. Surgical Complexity during conversion to TKA (Extra measures required)

Extra Component Required			
Stemed implant Wedge			
Required	334	4	
Total	1422	1422	
Percent	23.49%	0.28%	
Exposure technique/challenge			
Rectus snip Unattainable patella eversion			
Required	13	11	
Total	122	54	
Percent	10.66%	20.37%	
Balancing technique			
Lateral release Medial release Medial tightening Synovctomies			
Required	34	3	1
Total	139	34	41
Percent	24.46%	8.82%	2.44%
			9.76%

Table 4. Radiographic Outcome

	OR	95%CI	P	I _E
Loosening of femoral component	2.15	0.98,4.71	0.05	0%
Loosening of tibial component	3.14	1.33,7.43	0.009	75%
Impingement	11.97	3.46,41.43	<0.001	0%

Figures

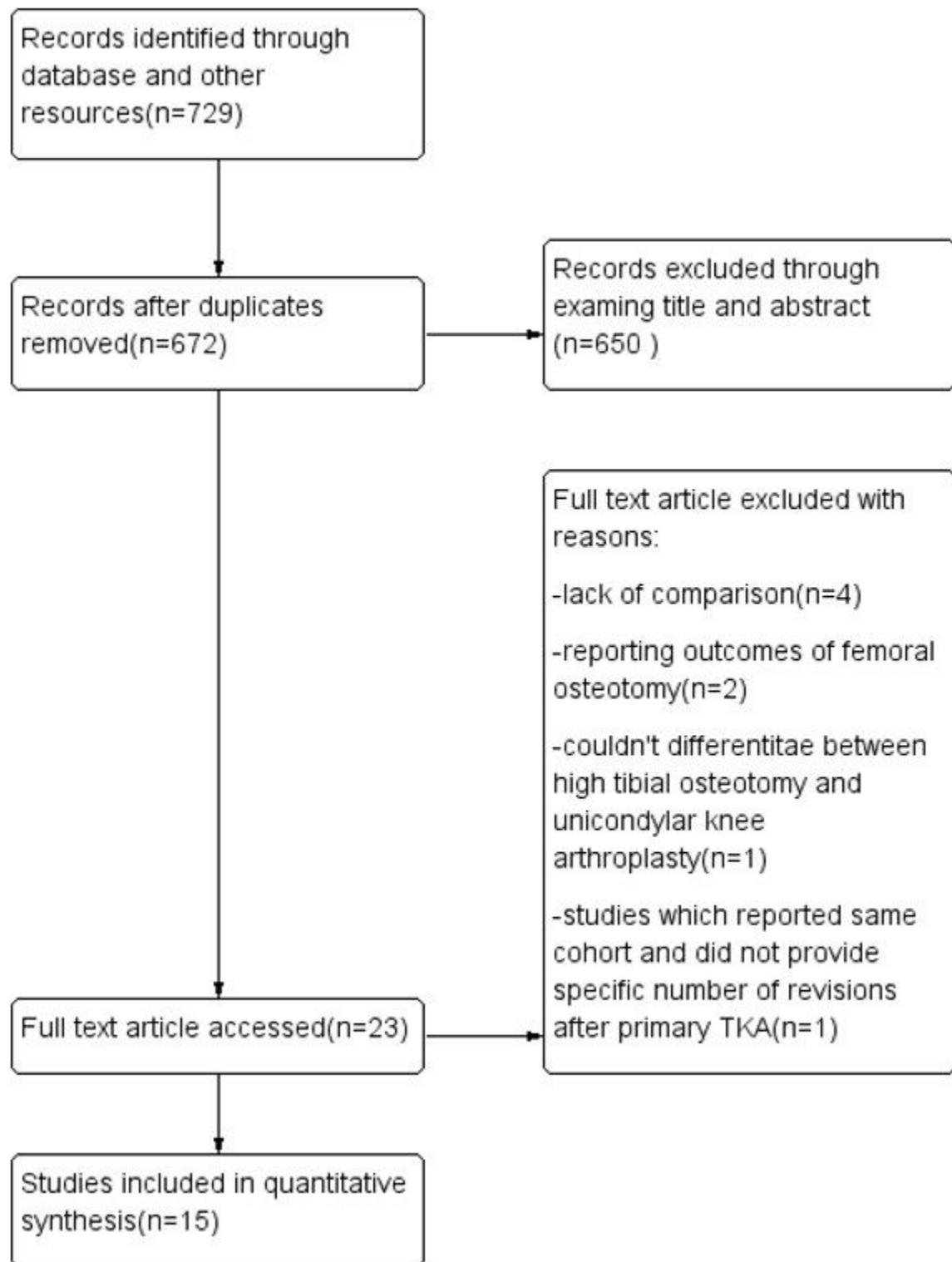


Figure 1

Flow diagram

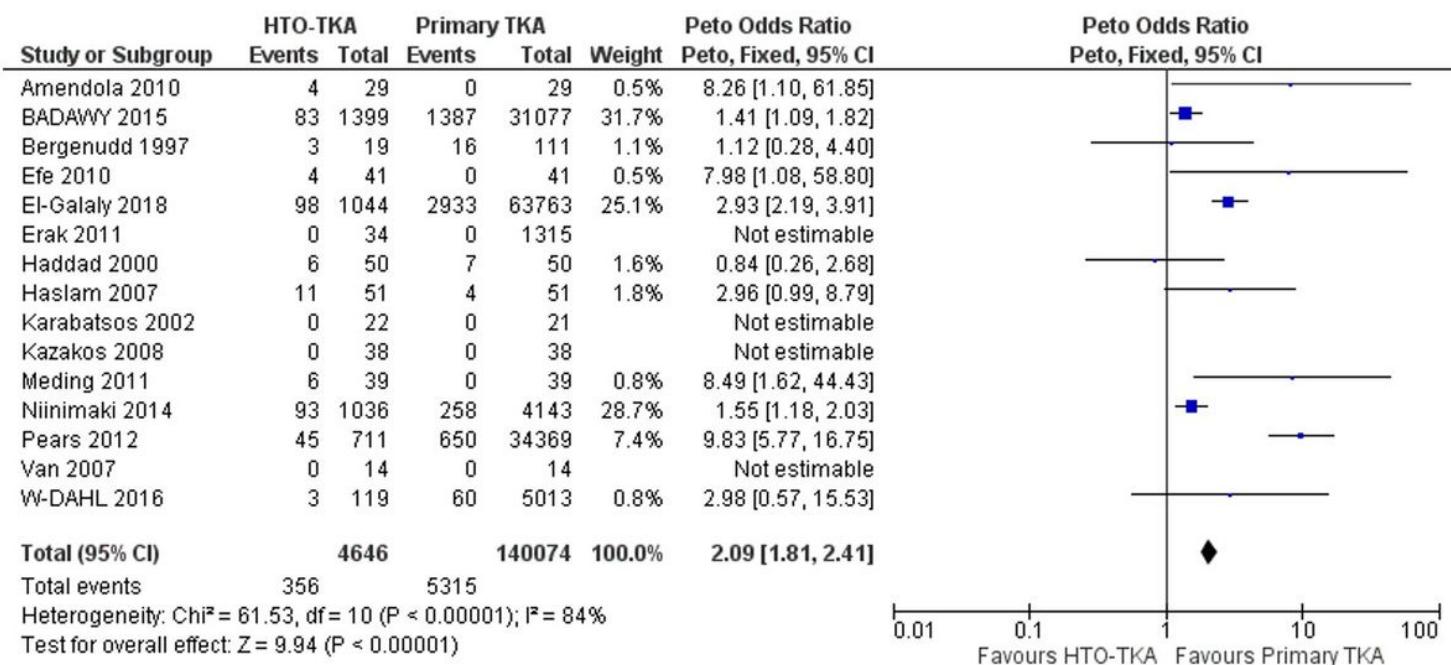


Figure 2

Revision in total

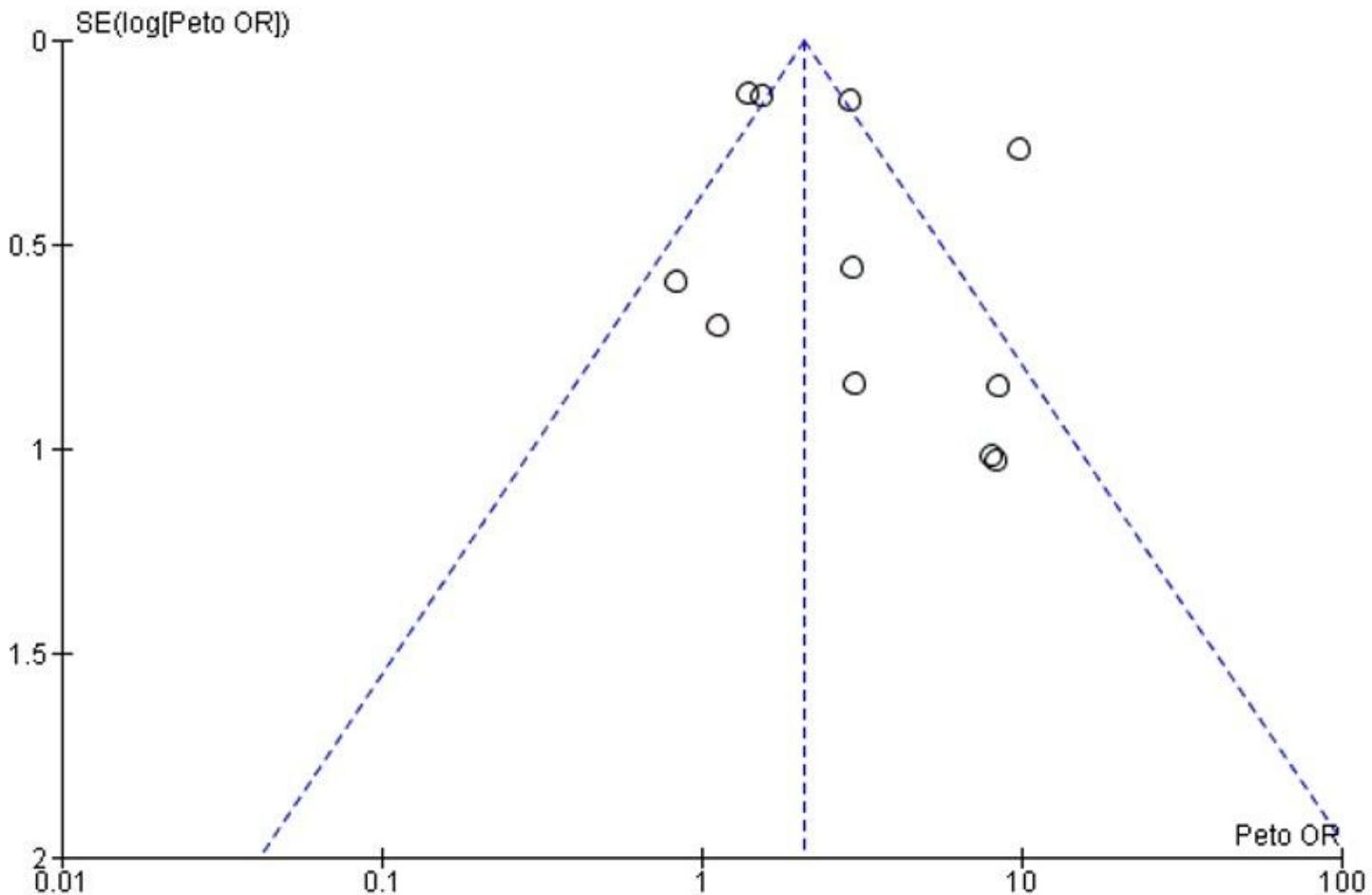


Figure 3

Funnel plot

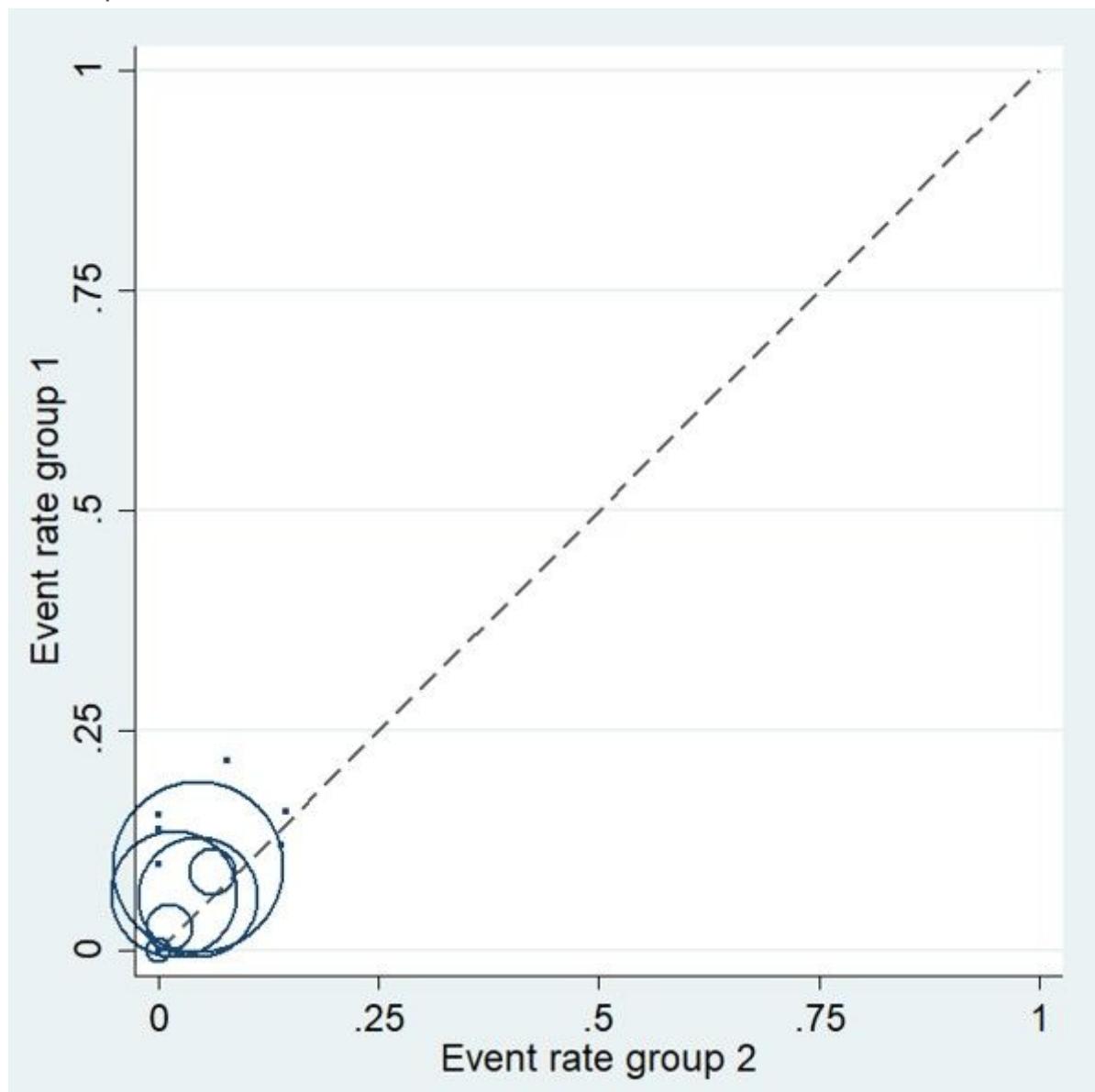


Figure 4

L'abbe plot

Supplementary Files

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