

Survival of Lateral Unicompartmental Knee Arthroplasty in Short-to-long-term Follow-ups: Meta-analysis

Zhao Guo

Affiliated Hospital of Hebei University

Ligang Qian

Affiliated Hospital of hebei university

Wenshan Gao

affiliated hospital of hebei university

Yunfei Wang

affiliated hospital of hebei university

Fei Gao

affiliated hospital of hebei university

Baohui Zhao (✉ zhaobaohui@tom.com)

affiliated hospital of hebei university

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Abstract

Background

The effectiveness of unicompartmental knee arthroplasty by lateral UKA remains poorly characterized as a limit of lateral UKA were operated for osteoarthritis (OA). However, the field of UKA surgery has rapidly expanded the usage of partly knee replacement in KOA patients with increased satisfaction, survivorship and functional outcomes.

Methods

A meta-analysis was conducted to evaluate the survivorship of lateral UKA with assessment with short-to midterm (<10years) and long-term (>10years) follow-up. Five databases were searched for eligible studies with search terms modified to the instructions of different databases. Twenty-three studies met the inclusion criteria and the pooling data were summarized in forest plots.

Results

The implant survivorship of lateral UKA in short-term (3 year) was 96% (95%CI, 0.95-0.97, $P<0.001$), mid-term (5 year) 95% (0.93-0.96, $P<0.001$), long-term (10 year) 89% (0.85-0.93, $P<0.001$), and 15 year (85.5%, 0.79-0.92, $P<0.001$). Sensitivity and subgroup analysis was conducted for potential source of heterogeneity.

Conclusion

Lateral UKA is a promising method of 90% survivorship over a short- to long-term follow up. Lateral UKA is a viable option in primary treatment of OA.

Introduction

Unicompartmental knee arthroplasty (UKA) can provided comparable or superior effects than total knee arthroplasty (TKA) in the treatment of unicompartmental knee osteoarthritis (OA).[1–2] However, the best treatment option for those patients has not achieved consensus as variation of surgical indications, contraindications, severe of symptoms, follow-up period, and implant design between studies may explain differences in results. Early operation of UKA has some limitations on surgical techniques and prosthesis, cement design leading to high rates of revision and implant complications, which the surgeons and patients had a choice of TKA ultimately.[3] Nowadays, it was a relief that UKA surgery keeps undergoing a technology refresh and renewal cycle, and satisfying outcomes and releases of operative techniques and implants are brought to practice frequently. Further, with an easily accessibility deal with revision, UKA have a promising future development.

In general, medial UKA takes up a majority of proportion of UKA than lateral UKA with higher prevalence of OA and osteonecrosis induced in medial compartment. Compared to medial UKA, lateral UKA takes up

a much less frequency of the surgery (5–10% of UKA)[4], and according to significant difference between lateral and medial compartment of knee joint in anatomy structure and functional result after surgery, the development of lateral UKA was obviously delayed to medial UKA. [5–6] lateral UKA to OA, the survival of implant varied differently in publication year; Ashraf et al reported 74.5% of survivorship of lateral UKA in 2002, while in the most recent studies, a survivorship over 95% was the majority.[7–11] These improvements and the high prevalence of lateral OA assessed in epidemiologic studies are significant clues and worthy a further investigation.

During our investigation, few large randomized trials were conducted to evaluate lateral UKA and the limited sample sizes of individual study were insufficient to illustrate the ability of lateral UKA. Therefore, we conducted a meta-analysis collecting all available evidences for a convincing conclusion with statistical power increased by meta-analysis and highlighted the potential of lateral UKA in the future usage of clinical settings to better guide surgeons and patients in the decision-making.

Material And Methods

This meta-analysis was conducted according to the guidelines of the PRISMA statement and do not require ethics approval or patient consent as the present study was based on previously published articles.

Search methods

We searched the Embase via Ovid, MEDLINE via Ovid, Web of Science, Cochrane Library and PudMed databases to Feb. 2021. Each database was searched with search strategy that is suitable to them. See supplementary material. Relative studies were also identified through cross-checking of references in the primarily identified studies and review articles. In this period, no publication time or language restriction was used.

Eligibility criteria

Two authors were responsible for the study selection and quality assessment section mentioned below independently. Studies were included in this analysis if they were: 1) studies that evaluated lateral UKA as a primary surgical treatment; 2) studies assessed implant survivorship and clinical outcomes of patients who underwent lateral UKA; 3) had a follow-up of 3 years or longer; 4) reported the confident interval of implant survival rate. Instead, the following studies were excluded due to: 1) missing data or insufficient data; 2) studies reported their conclusion based on the same cohort, and in this circumstance, only the study with the most comprehensive data was included; 3) studies not published in English; 4) study designs, such as, case reports, reviews, commentaries, editorials or conference abstracts were declined; 5) animal experiments or human in vitro work were also excluded. Any discrepancies were resolved by discussion.

Data extraction

The same two authors completed the need for data extraction using a standardized data collection form. Following data were extracted: general information (publication year, study design, first author's name), sample size (number of participants, number of knee underwent lateral UKA), baseline characteristics (age, sex), survivorship of the implants, mode of failure. When we cannot contact the corresponding author, the survival data were extracted from their Kaplan-Meier curves for its advantage that it accounts for patients who were lost to follow-up or died. For the analysis of survivorship, failure was defined as revision for any reason (defined as operations in which at least one of the components was changed), re-operations, aseptic revision and dislocation of the bearing.[12]

Assessment of methodological quality

As the previous systematic review mentioned, the quality of studies available was low.[13] Therefore, a quality assessment was conducted using the Newcastle–Ottawa Scale (NOS), which was accommodated to the studies included in this meta-analysis.[14] The NOS scores study in the assessment of three domains: (1) selection of study groups; 2) ascertainment of endpoints; 3) follow-up of outcomes; 4) prospective calculation of the study size, respectively.

Statistical analysis

We used random effects models to calculate implant survivorship and 95% confidence intervals. The heterogeneity between studies was assessed using the χ^2 test and the inconsistency index (I²). An I² > 50% with P < 0.05 from the χ^2 test is indicative of significant heterogeneity. In this case, a random effect model was chosen to pool the data. Otherwise, a fixed effect model was used. Sensitivity and subgroup analysis were also conducted to identify the source of heterogeneity in the eligible studies. Subgroup analysis was conducted between fix-bearing and mobile bearing prosthesis, lateral parapatellar approach (LPPA) and minimally invasive-surgical approach (MIS), publication year in between 2000–2010 and 2011–2020.

Publication bias was analyzed by using the Deeks funnel plot and an asymmetry test. P < 0.05 is considered the existence of publication bias.

All analyses were performed using Stata version 15.1 (StataCorp LP). Engauge Digitizer version 10.8 was used when only Kaplan-Meier survival curve was reported in the publication.

Results

Results of search

Finally, 3,921 studies were identified by the five databases and 1,497 were left after removing duplicates. Those studies went into a screening based on their titles and abstracts. In this process, studies with topic differed markedly with our eligibility were excluded, so did the studies not published in English. Finally, twenty-three studies were included in this meta-analysis.[7–12–15–31] The meta-analysis extracted the survival data of lateral UKA from those 23 included studies with a total of 5,371 patients underwent

lateral UKA over two decades. Detailed selection was displayed in Fig. 1. The study quality of most studies was high and moderate. Four studies were graded as having poor quality for the reason that they comprised retrospective analyses. The study quality scoring is displayed in supplementary material table 1.

Table 1
Characteristic of included studies

Study	Year	Age	Sample size		Insert design	Operative method	Maximum follow-up
			Male	Female			
Argenson et al. [15]	2008	61 ± 7	15	24	fixed	not reported	15
Ashraf et al.[7]	2002	69 ± 11.5	11	68	fixed	LPPA	15
Baker et al.[16]	2012	63.1 ± 18.25	900	1152	fixed	not reported	5
Burger et al.[17]	2020	64.4 ± 11	69	102	fixed	not reported	5
Deroche et al.[12]	2020	68.8 ± 10.5	63	205	fixed	LPPA	15
Fornell et al.[18]	2018	63 ± 10.73	/	/	mobile	MIS	5
Gill et al.[19]	2019	58 ± 5.5	7	7	fixed	LPPA	10
Gunther et al.[20]	1996	68 ± 12	4	47	mobile	LPPA	10
Heyse et al.[21]	2011	53.7 ± 5.8	/	/	fixed	LPPA	15
Kennedy et al.[11]	2020	65 ± 12.75	94	204	mobile	MIS	10
Liebs et al.[22]	2013	73.6 ± 11.75	/	/	fixed	LPPA	10
Lustig et al.[23]	2014	72.2 ± 3.0	8	39	fixed	LPPA	10
Marson et al.[24]	2013	57.8	/	/	fixed and mobile	LPPA	3
Mohammad et al. [8]	2020	64.5 ± 12.3	351	641	mobile	LPPA	10
Newman et al.[2]	2017	71 ± 12	17	41	mobile	MIS	3
O'Rourke et al.[26]	2005	70.9 ± 10.63	51	52	fixed	not reported	15
Romagnoli et al. [10]	2020	57.1 ± 10.4	4	9	fixed	LPPA	5

LPPA lateral parapatellar approach, MIS minimally invasive surgical technique through a lateral parapatellar incision without patellar eversion

Study	Year	Age	Sample size		Insert design	Operative method	Maximum follow-up
			Male	Female			
Smith et al.[27]	2014	64.8 ± 13.75	32	68	fixed	LPPA	5
Streit et al.[28]	2012	60 ± 11.25	20	30	mobile	LPPA	3
Tu et al.[9]	2020	70.2 ± 8.8	38	83	fixed	MIS	5
Walker et al.[29]	2018	65 ± 13	90	237	mobile	MIS	5
Weston-Simons et al.[30]	2014	64 ± 14.5	91	167	mobile	MIS	5
Zambianchi et al. [31]	2019	62.1 ± 9.5	16	50	fixed	MIS	3
LPPA lateral parapatellar approach, MIS minimally invasive surgical technique through a lateral parapatellar incision without patellar eversion							

Survival of the prosthesis

The overall results of meta-analysis on lateral UKA revealed a high survival of implant. The revision rate is low, and the patient satisfaction is relatively high. Further, we estimated the survivorship according to different time follow-up. These results showed that the implant survivorship of lateral UKA in short-term (3 year) 96% (0.95–0.97, $P < 0.001$, $I^2 = 74.8\%$), mid-term (5 year) 95% (0.93–0.96, $P < 0.001$, $I^2 = 77.7\%$), long-term (10 year) 89% (0.85–0.93, $P < 0.001$, $I^2 = 79.2\%$), and 15 year (85.5%, 0.79–0.92, $P < 0.001$, $I^2 = 63.6\%$).(Fig. 2,3)

Sensitivity analysis was conducted to find out the source of heterogeneity (data not show). In the analysis of short-term follow-up, the study of Walker et al was found to be a potential source of heterogeneity; by omitting the study, total heterogeneity was decreased to 69.7% but did not showed an obvious reduction. The relatively high heterogeneity remains unresolved. Similar result was also found in the analysis of short-to-mid-term follow-up. The results of the sensitivity analysis were consistent with the original results. No study was found to be a potential source of heterogeneity. During the analysis of long-term follow-up, the study of Lusting 2014 et al was assessed as potential source of heterogeneity; omitting the study decreased heterogeneity to 20.3% and the satisfactory survivorship of implant remained unchanged. Finally, in the sensitivity analysis of 15-year-follow-up, omitting the study of O'Rourke decreased heterogeneity to 26.6% and no significant heterogeneity was observed among the pooled result.

In the subgroup analysis stratified by fixed-bearing implant and mobile-bearing, comparable implant survival rates were found between implant types while fix-bearing implants were 4–5% higher than mobile bearing. Both of them have a survivorship in long-term follow-up significantly lower than short-to-mid-term follow-up with approximately a margin of 10%. For surgical approaches, MIS appeared to have a superior effect than conventional lateral parapatellar approach in all follow-ups. According to publication year, the average survivorships of the 2011–2020 studies were slightly higher than the previous decades. Results of subgroup analysis were summarized in Table 2.

Table 2
Results of subgroup analysis

Subgroup	Follow-up	number of study	estimate survival	95%CI	p
Type of implant					
Fix bearing	3 years	11	97.4	0.96–0.98	< 0.001
	5 years	11	96.0	0.94–0.98	< 0.001
	10 years	6	89.6	0.85–0.94	< 0.001
Mobile bearing	3 years	7	93.6	0.91–0.97	< 0.001
	5 years	7	91.8	0.89–0.94	< 0.001
	10 years	4	87.4	0.84–0.91	0.32
Surgical approach					
LPPA	3 years	11	95.3	0.94–0.97	< 0.001
	5 years	9	94.5	0.92–0.97	< 0.001
	10 years	7	89	0.84–0.94	< 0.001
	15 years	3	82.8	0.70–0.96	0.006
MIS	3 years	6	96.0	0.92–1.00	< 0.001
	5 years	6	93.7	0.89–0.99	< 0.001
	10 years	3	87	0.80–0.94	0.20
	15 years	1	84	0.71–0.97	-
Not report or contain two approaches	3 years	2	97.4	0.95–1.00	< 0.001

CI confidence interval, LPPA lateral parapatellar approach, MIS minimally invasive-surgical approach

Subgroup	Follow-up	number of study	estimate survival	95%CI	p
	5 years	3	95.5	0.83–0.99	0.012
	10 years	1	89	0.83–0.95	-
	15 years	1	87.7	0.82–0.94	-
Publication year					
2000–2010	3 years	3	94.6	0.89–1.01	< 0.001
	5 years	3	94.1	0.89–0.99	< 0.001
	10 years	4	88.4	0.84–0.94	0.509
	15 years	3	86.4	0.81–0.92	0.51
2011–2020	3 years	16	95.6	0.95–0.97	< 0.001
	5 years	15	94.7	0.93–0.97	< 0.001
	10 years	7	89.1	0.84–0.94	< 0.001
	15 years	2	84.8	0.70–1.00	0.004
CI confidence interval, LPPA lateral parapatellar approach, MIS minimally invasive-surgical approach					

According to the Deeks funnel plot asymmetry test, there was publication bias observed in the evaluation of 3-year survival ($p = 0.04$). Except that, no publication bias was detected among the studies in 5-year survival ($p = 0.21$), 10-year survival ($p = 0.26$), or 15-year survival ($p = 0.18$).

Discussion

We believe this is the first meta-analysis collecting all available evidences to confirm a statistically powerful conclusion of the satisfactory outcomes from lateral UKA. UKA has allowed an impressive improvement of life quality and survival rates of more than 95% in recent practice.[8–9–13] However, a great mass of those achievements were medial UKA's credit. Differences between medial and lateral UKA

in anatomy, biomechanical and clinical manifestation are objectively disadvantages make lateral UKA difficult to develop.

The current meta-analysis conducted a pooling calculation with short-term, mid-term and long-term advantages of lateral UKA. Over 95% of implant survivorship of lateral UKA was observed in 3-year and 5-year follow-ups. It also offers good long-term success of lateral UKA with an 86% survivorship in 10-year and 15-year follow-ups. With the exception of survivorship, Smith et al showed that patients' pain was greatly improved from 10 to postoperatively 50 (best) in the assessment of median AKS pain score. Similarly, WOMAC pain score was also statistically improved after operation.[27] Kinsey et al looked at the range of knee flexion assessed a 22.6° improvement postoperatively.[32] Complications were assessed by Bonanzinga et al in a systematic review previously.[13] They noted that the most frequent complication was the progression of medial compartment OA and bearing dislocation in 61/2651 and 51/2651 patients indicating a low complication rates (1.9–2.3%) of lateral UKA. During our subgroup analysis, it suggested that the survivorship of lateral UKA are statistically significant different in fixed-bearing and mobile bearing implants. Whilst the fixed-bearing implants have showed an implant survivorship (90–97%) in short-to-long term follow-ups, mobile bearing lateral UKA have showed a significantly lower survival in (87–94%) with the same follow-ups. There have long been concerns on the mobile bearing. Initially, those mobile bearing prosthesis were designed to lower contact stresses and wear with enlarged contact area. But when it was used clinically, the first generation lateral Oxford UKAs have shown a 21% failure rate due to a flabby ligament of lateral compartment.[4] After that, subsequent regeneration of Oxford UKA reduced dislocation rate of implant to 6.6%.[33] Nevertheless, the improvement of mobile bearing was slightly inferior to fixed-bearing and studies on mobile bearing were less than fixed-bearing. Therefore, further study on mobile bearing implants is required and fixed bearing is recommended in the operation of lateral UKA.

The trend of accepting lateral UKA as an OA treatment actually steady increased with time. The treatment was not approval by both surgeons and patients for the high implant complication rate and worse clinical efficacy at the beginning, but surgical techniques and implants had made great advances during the last two decades. Nowadays, researches have recommended the usage of UKA in the treatment of osteoarthritis as comparable clinical outcomes and survivorship was constantly being proved in recent studies.[9–20–34–35] In contrast, TKA was criticized of unsatisfactory functional outcomes of knee and the overall satisfaction mostly felt on “feeling normal”.[36] UKA has superior functional outcomes than TKA as UKA have achieved a comparable efficacy and lower complication rate when compared to TKA in short-term follow-up assessment.[9] [37] RCTs have also suggested that UKA has better ROM knee flexion with pain relief and function compared to TKA.[1–2–38–39] More than that, long-term survivorship is necessary to be assessed when comparing TKA and UKA in the treatment of unicompartmental knee osteoarthritis and UKA should be highly-regarded.

In nowadays clinical settings, lateral UKAs are performed much lesser than medial UKA and the excellent performance of medial UKAs cannot be regarded as the same to lateral UKA. It is of great significance to know perfectly well what features differs lateral UKA from medial UKA in the promotion of UKA in the

treatment of lateral OA specifically. Biomechanical differences are the most often talk about topic. Compared to medial compartment, the laxity of lateral stabilizing structures is increased with the adductor moment of the knee leading to higher possibility of implant dislocation, especially in the cases of mobile implants.[40] There is also another consideration that lateral OA is usually combined with dysplasia of lateral condyle, which a relatively conservative resection is recommended to tibial and distal femoral avoiding a total correction on the valgus deformity.[41] It is a promising and reliable method to treat osteoarthritis when surgical indication of lateral UKA, advanced surgical techniques, fixed-bearing implant and a precise location of prostheses was strictly controlled.

Still, many technical challenges exist and several limitations of this study should be taken into consideration when interpreting it. The meta-analysis on survivorship was a single rate analysis without comparison. A comparison with TKA or medial UKA may be a good choice but the limit operation of lateral UKA is the concern to conduct a comparative study. Subsequently, quality of studies could threaten the study results. All included studies were observational study with cohort and registry-based study, which might resulted in heterogeneity and publication bias was observed in the analysis of 3-year follow-up. Moreover, compared to short-term efficacy, the number of long-term study is limited in the study and so did a follow-up for up to 30 year. Future studies providing sample randomization, longer follow-up and comparison to other treatments are required to improve the evidences regarding lateral UKA.

Conclusion

In conclusion, the lateral UKA has a 90% survivorship over a short- to long-term follow up. Those results are acceptable for patients who pursue for knee flexion and a fixed-bearing prosthesis is recommended. Further research on mobile bearing is required and it can adopt a comparison between fixed-bearing and mobile bearing UKA in the lateral compartment.

Abbreviations

LPPA lateral parapatellar approach, LUKA lateral unicompartmental knee arthroplasty, OA osteoarthritis, TKA total knee arthroplasty, NOS Newcastle–Ottawa Scale, MIS minimally invasive-surgical approach, RCT randomized control trial

Declarations

Declarations

Not applicable.

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The study received no funding support.

Conflicts of interest

The authors declared no conflicts of interest.

Ethics approval

This analysis was based on previous published studies, and as such, no ethical approval and patient consent were required.

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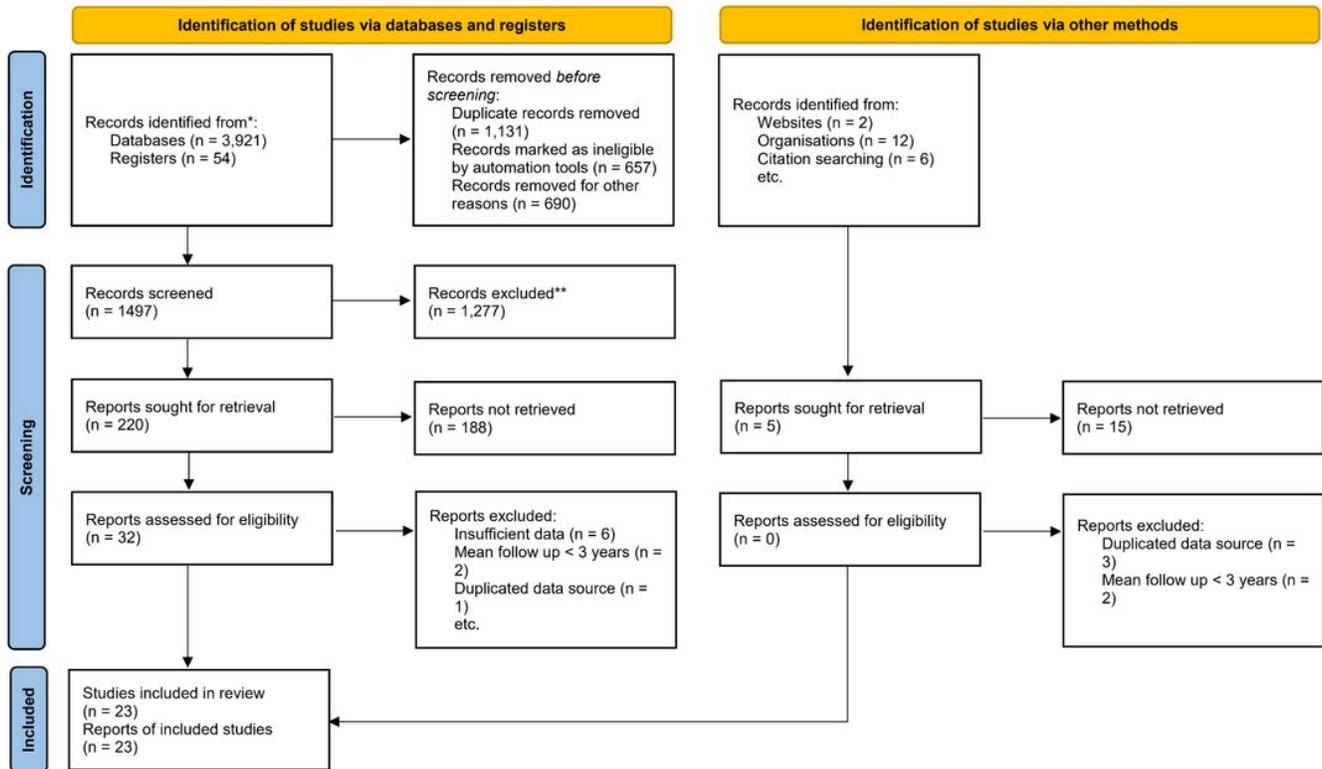
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Figures

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Figure 1

Flow chart of study selection

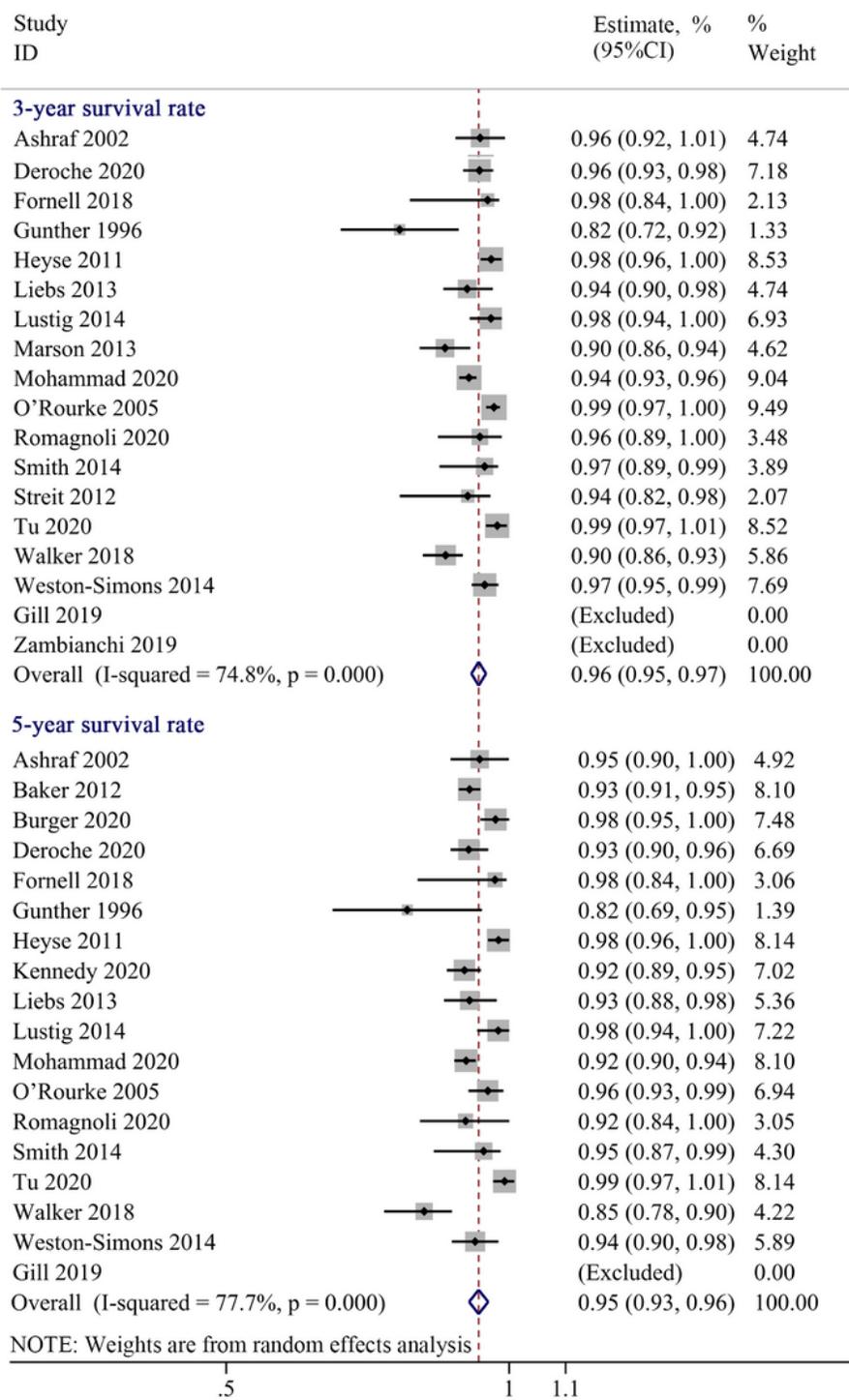


Figure 2

Forest plot of short-to-mid-term survival rate

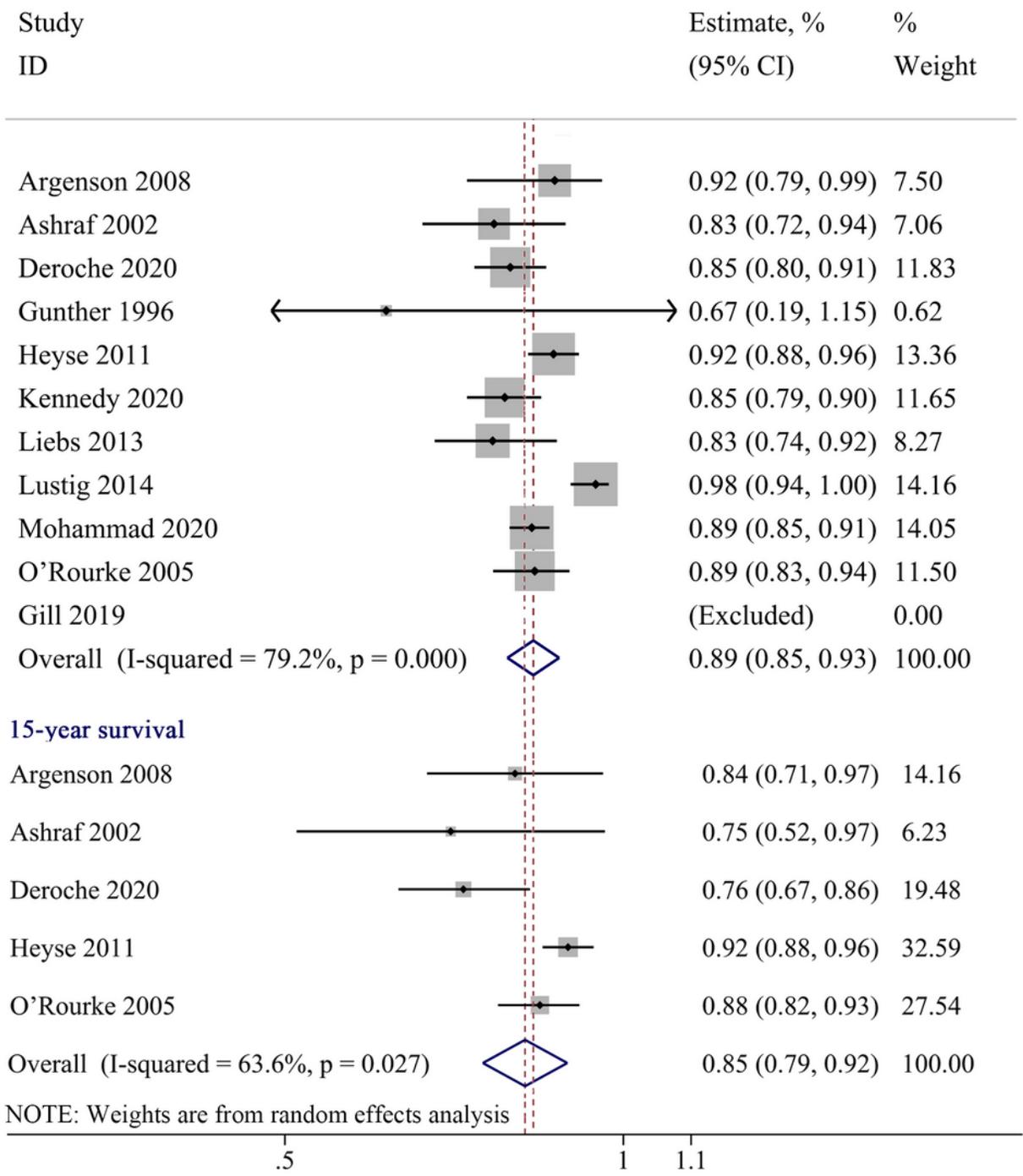


Figure 3

Forest plot of long-term survival rate

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [supplementarymaterial.docx](#)