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Review article

Rotating-hinge knee prosthesis as a viable option in primary surgery: Literature review & meta-analysis

Ali Abdulkarim [a,*], Anna Keane [b], Shu Yang Hu [b], Lachlan Glen [b], Dermot J. Murphy [c]

[a] *Trauma & Orthopaedic Department, Cambridge University Hospital, Addenbrooke's Hospital, Cambridge, United Kingdom*
[b] *Royal College of Surgeons, Ireland*
[c] *University of Limerick, Ireland*

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ABSTRACT

Background: Rotating-hinge knee replacements are usually reserved for revision surgeries, when the extent of soft tissue loss makes a constrained implant more suitable. They remain an uncommon choice in primary surgery when the soft tissue loss is not as extensive.
Methods: We completed a systematic review and meta-analysis to assess patients who underwent a Total Knee Replacement (TKR) with the rotating-hinge prosthesis in the primary setting. We searched PubMed and Embase for articles published in the ten years prior June 2017: Prosthesis survival rates, causes of failure, and clinical/functional scores were the primary outcomes. Twenty-one articles met the inclusion criteria for meta-analysis. Articles were grouped into (1) non-tumour ($n = 11$) and (2) tumour indications ($n = 10$). Survival data was summarized in forest plots, generated using Stata.
Results: We found that for certain indications the prosthesis has impressive survival rates and functional outcomes. Short-term (1–5 year) prosthesis survival in non-tumour cases was 92% (95% CI, 87–98%) and 77% (95% CI, 68–87%) in tumour cases. Mid-term (6–10 year) survival was 82% (95% CI, 74–89%) and 69% (95% CI, 57–81%) in non-tumour and tumour studies respectively. In analysis of clinical scores, patients showed a significant improvement in their pain score. Infection was the most commonly cited cause of prosthesis failure in both non-tumour and tumour studies, attributing to 31.5% and 37.6% of failures respectively. Aseptic loosening, dislocation and fracture were also commonly cited complications.
Conclusion: We concluded that the rotating-hinge knee prosthesis is a viable option in primary surgery when there is extensive soft tissue destruction surrounding the joint.
Level of evidence: I.

1. Introduction

The total knee replacement (TKR) is one of the most successful surgical procedures of modern medicine. Its primary purpose is to restore function and reduce pain. Since TKRs were first performed, both surgical technique and the technology available have advanced enormously. One aspect of this advance is the large selection of prostheses that are now available. Among them is the hinge prosthesis, a type of constrained implant.

When it was first introduced these implants allowed only flexion and extension. This design, known as the fixed-hinge prosthesis, was found to transfer considerable stress to the interface between the bones and the implant, leading to unacceptably high rates of complications [1,2]. Because of the high complication rates, the hinge prosthesis became an uncommon choice of implant.

Subsequent designs of the prosthesis have attempted to address these issues. Especially important, has been the modification allowing for axial rotation on the tibial plateau [3]. This modification reduced the stress that was transferred to the bone-implant interface. This design is known as the rotating-hinge prosthesis and is now the version most often used.

Currently, the rotating-hinge prosthesis is reserved for cases in which the defects in bones or soft tissue render an unconstrained prosthesis unsuitable. The structural characteristics of the knees in which rotating-hinge prostheses are employed include severe imbalance of ligaments non-correctable by soft tissue release, constitutional deformity and malunion of the distal femur in an elderly subject. Bone defects resulting from a primary or metastatic tumour lesions are also indications for rotating-hinge [4]. In practice, this is often when a primary implant has failed and revision is required [2,5,6].

* Corresponding author.
E-mail address: ali.abdulkarim@addenbrookes.nhs.uk (A. Abdulkarim).

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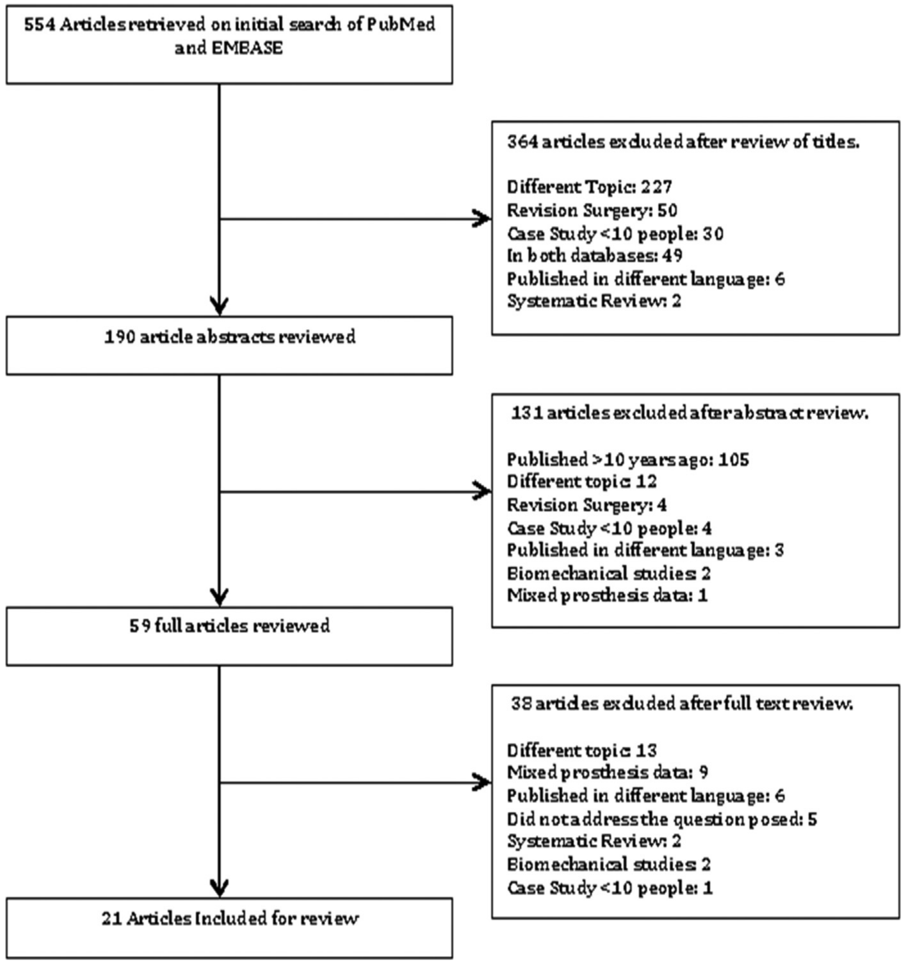

Fig. 1. Search results and exclusion process.

However when the initial soft tissue loss or bony defect is extensive, the rotating-hinge prosthesis is sometimes used as the primary implant. Our study aims to establish a clearer picture of the survival and function of the rotating-hinge prosthesis when it is used in primary surgery. We also attempt to establish the common reasons for failure of the prosthesis. In doing so, we aim to elucidate the optimal circumstances for this procedure and facilitate in the management of patient expectations.

2. Methods

2.1. Searching

A comprehensive search was carried out of the PubMed and Embase databases for articles on patients who underwent TKR with the rotating-hinge prosthesis in the primary setting. The reference lists of each study were reviewed to identify additional studies. The titles of the articles were reviewed first; then the abstracts were reviewed; and finally the complete articles were assessed for inclusion in the review. Two authors reviewed the articles independently and inclusion was by consensus (Fig. 1).

2.2. Study selection

We only included articles that have been published in the last ten years, in order to account for the advances in the design and surgical techniques that have occurred recently, and which would not be reflected in articles published before this period; articles which reported only on patients who received a rotating-hinge prosthesis in the primary setting; articles which reported on the prosthesis in both the primary and revision setting, but in which it was possible to separate the patients who received the prosthesis as a primary implant from the patients who received the prosthesis as a revision implant; articles which reported on at least ten patients who received the rotating-hinge prosthesis; articles which included data addressing at least one of the issues we were concerned with (survival/cause of failure); and articles which were written in English.

2.3. Outcomes

The primary outcomes of interest included; prosthesis survival rates (at various time intervals), causes of failure, and clinical/functional scores. Prosthesis survival was defined as a knee replacement that has remained functional at various time points following initial surgery. Prosthesis failure is defined as a need for extremity amputation or revision RKA.

2.4. Risk of bias assessment

The internal validity of the studies was assessed using the MINORS criteria [7]. This validated tool is designed to assess the methodological quality of non-randomized studies. The included non-tumour studies had an average score of 10.2 out of 16. Included tumour studies had an average score of 9.9 out of 16. Two reviewers generated scores independently, and when disagreements arose a third reviewer was consulted.

2.5. Data extraction

Two authors independently reviewed each article in an effort to extract relevant variables. There was variation in what was reported on a study-to-study basis, but when available we extracted study demographics (age, gender, indication), sample sizes, prosthesis survival rates, functional scores, clinical scores, and causes of failures.

2.6. Synthesis of data

Survival data was summarized in forest plots, generated using Stata [8]. Prosthesis survival data was analyzed by means of weighted proportions (based on study size) and the application of a random effects model. This was accomplished using the Metaprop command within Stata [9]. Additionally heterogeneity between studies was assessed. Studies were grouped into either tumour or non-tumour indications in an effort to homogenize the study populations to some degree.

We identified twenty-one articles for inclusion, which included 2361 prostheses. After reviewing the articles we divided them into two groups. The first group ($n = 11$) included the articles on the rotating-hinge prosthesis when it was used for non-tumor indications, primarily osteoarthritis and rheumatoid arthritis. The second group ($n = 10$) included the articles on the rotating-hinge prosthesis when it was used in patients who had tumors of the femur or tibia.

We divided the articles in this manner for two reasons. First, there is a difference in the reasons for failure in the two groups: recurrence of the tumor can lead to failure of the prosthesis in patients with bone tumors, whereas it is not a reason for failure in patients with severe arthritis. Second, there is an age difference between the patients in the two groups: the patients who have the rotating-hinge prosthesis implanted because of tumors are on average much younger than the patients who have it implanted for non-tumor indications.

3. Results

3.1. Non- tumour indications

Eleven articles on rotating-hinge prosthesis for non-tumour indications in primary surgery were included in the study [4,10–19]. Of these articles, 72% (range 44–90.5%) of patients were female and the mean patient age was 68.3 years (range 21–99). The most common indication for surgery was osteoarthritis, with an incidence of 100% in two articles. Other indications included rheumatoid arthritis, post-trauma arthritis, supracondylar malunion and Charcot arthropathy. One study looked exclusively at rotating-hinge prosthesis in patients with poliomyelitis affected limbs [18]. A total of 1425 prosthesis were included in the non-tumor analysis.

3.1.1. Survival of the prosthesis

The rates of survival to revision of the prosthesis ranged from a ten-year survival of 100% in the article by Kowalczewski et al., to 73.7% at 12.3 years in the article by Bae et al. [10,16]. The survival rate for the prosthesis in each of the articles is presented in Figs. 2–4. The overall survival rates for 0–5, 6–10, and 11–15 year follow up were 92%, 82%, and 88% respectively. It should be noted that Kowalczewski et al. had a small sample size ($n = 12$), which may partly account for their impressive results. There was considerable variety in the length of follow-up in the papers (Table 1), so comparison between them is not unproblematic.

3.1.2. Clinical scores

The most frequently used scoring system to assess non-tumor patients post-operatively was the Knee Society Score (KSS), used in seven articles. This scoring system has two components; the clinical score, which measures the reduction in a patient's pain, and a function score which measures the improvement in a patient's function. The maximum score in both of these is 100. The mean reported post op functional score was 67.9 (SD = 17.8, Range 0–100), while the mean reported post op clinical score was 84.9 (SD = 10.3, Range 28–100). Some studies also provided pre op scores, allowing a mean improvement in those studies to be calculated. Of those studies, the mean improvement in clinical score from pre to post op was 39.7 (SD = 21.0), while the mean improvement in functional score 40.2 (SD = 8.3).

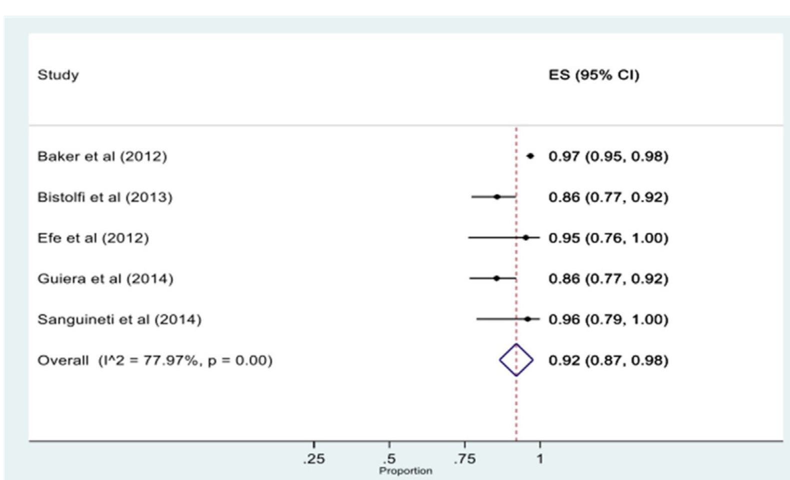

Fig. 2. Short-term (1–5 year) prosthesis survival in non-tumour cases; 92% (95% CI, 87–98%) of prostheses survived after 1-5 years follow-up.

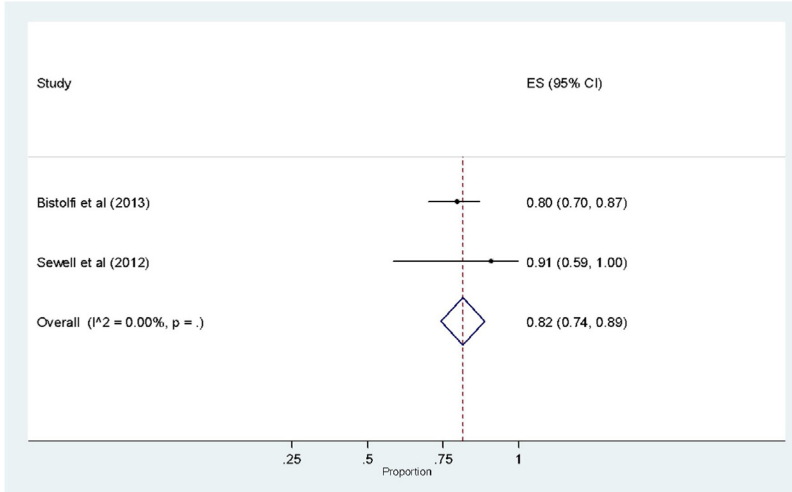

Fig. 3. Mid term (6–10 year) prosthesis survival in non-tumour cases; 82% (95% CI, 74–89%) of prostheses survived after 6-10 years follow-up.

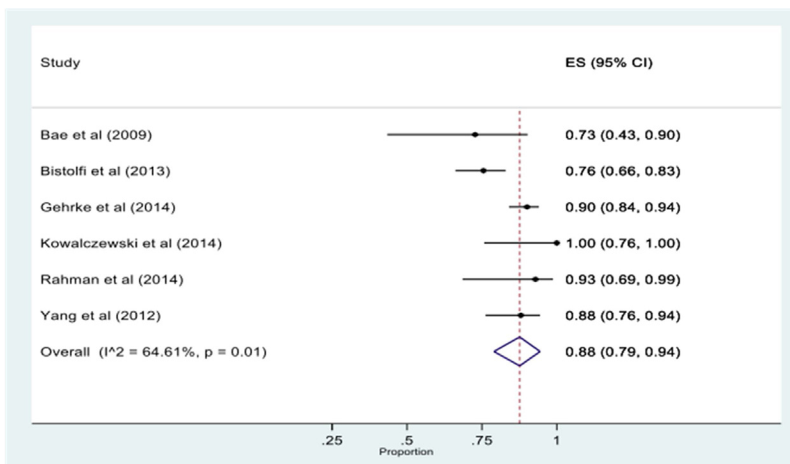

Fig. 4. Long-term (11–15 year) prosthesis survival in non-tumour cases. 88% (95% CI, 79–94%) of prostheses survived after 11–15 years follow-up.

3.1.3. Failures

Ten of the articles listed the reasons for the failures in non-tumor patients (Table 2). Infection was the most common cause of failure, making up 31.5% of all failures reported. Dislocation and aseptic loosening tied as the second most frequently cited causes of failure. Of the ten articles, six included information on the time-to-failure for each complication, which is summarised in Table 1 [4,10,11,17–19]. Of these articles, the complication leading to the earliest failure was periprosthetic fracture, with a mean time-to-failure of 0.79 years.

3.2. Tumours

Ten articles on rotating-hinge prosthesis for tumour-related indications in primary surgery were included in the study [20–29]. Of these articles, 60% (range 46.3–70%) of the patients were men and the mean patient age was 33.2 years (range 9–81 years).

3.2.1. Survival of the prosthesis

The overall prosthesis survival rates for 0–5 and 6–10 year follow up were 77% and 69% respectively. The rates of survival of the prosthesis in patients with tumors of the bone are not as high as they are in non-tumor patients. The primary reason for this is that recurrence of the tumor is a cause of failure in this group only. In Fig. 5 it should be noted that the patients in the article by Natarajan et al. were treated for giant cell tumour, a benign tumour of the bone, which makes recurrence less likely [27]. It is also a condition for which chemotherapy and radiotherapy are not indicated. These treatments of malignant bone tumors can leave patients immunosuppressed and susceptible to infection.

In all the other studies, the large majority of patients had malignant bone tumors. The highest prosthesis survival rate in patients with malignant bone tumors is in the case series by Friesenbichler et al., which demonstrated survival of 92% (95% CI, 74–99%) Fig. 6. However, the follow-up for this study was only five years. In the other five studies at 6–10 years follow-up, the rate of survival is 80% or less. As in the studies on the prosthesis in non-tumour patients, the length of follow-up is not uniform so comparison between the studies is not unproblematic (Table 3). Prosthesis failure did not include death of patients.

3.2.2. Clinical scores

The scoring system used most frequently to assess the function of the prosthesis in the articles we reviewed was the Musculoskeletal Tumor Society (MSTS) scoring system, which was used in six of the articles. The maximum points score in the MSTS is 30, but can

Table 1
Summary of studies of the rotating-hinge knee prosthesis for non-tumour indications.

Authors	N° of rotating-hinge prostheses	Mean age (years, range)	Mean length of follow up (range)	Survival	Clinical Score	Causes of failures
Bae et al., 2009	11	60.1 (46–68)	12.3 years	72.73% at minimum 10 yr follow up	Knee Society Score (KSS) mean score Clinical: 44.9 pre op, 95.0 post op Functional: 45 pre op, 93.6 post op	Infection 1 (9.1%) Dislocation 2 (18.2%)
Baker et al., 2012	964 (a 43 functional scores available) from a National Joint Registry	73 (21–99)	7 months for Patient-Related Outcome Measures (PROM)	5 year: 96.8%	Oxford Knee Score (mean improvement) 17.6 points	Infection 8 (0.83%) Periprosthetic fracture 4 (0.41%) Aseptic loosening 3 (0.31%) Misalignment 2 (0.2%) Dislocation 1 (0.1%) Unexplained pain 1 (0.1%) Other 1 (0.1%)
Bistolfi et al., 2013	98 (26 implants lost to follow-up)	69.1 (34–84)	174.1 months (156–193)	15 year: 75.8%	Hospital for Special Surgery (HSS) 17.8 points, mean improvement	Septic loosening 6 (6.1%) Dislocation 5 (5.1%) Aseptic loosening 3 (3.1%) Hinge rupture 2 (2%) Periprosthetic fracture 1 (1%) Femoral stem rupture 1 (1%)
Efe et al., 2012	21	73.7	56 months (19–93 months)	95% at follow up	Knee Society Score (KSS) mean score Clinical: 13 pre op, 82 post op Function: 29 pre op, 58 post op	Recurrent dislocation 1 Peri-prosthetic fracture 1 Infection 1
Gehrke et al., 2014	141	67 (26–88)	13.5 years	13 year: 90%	HSS (% of patients classified as) Excellent: 54% Good: 20% Fair: 12% Poor: 14%	Patellofemoral complications 6 (2.5%) Deep infection 5 (2%) Failure of hinge 3 (1%) Instability 2 (0.8%) Femoral component loosening 1 (0.5%) Extensor mechanism disruption1 (0.5%)
Guiera et al., 2014	90	72.3 (48.0–90.0)	24 months	2 year: 85.4%	KSS mean score (mean improvement) Clinical: 94.1 (71.6) Function: 72.1 (29)	Not disaggregated into primary and revision
Kowalczewski et al., 2014	12	67.5 (43–83)	Minimum of 10 years (10–12 years)	100% at follow-up	KSS mean score (mean improvement) Clinical: 86 (68.7)	No failures
Sanguineti et al., 2014	24	74 (50–84)	42.2 months	96% (5 year)	KSS mean score (both post op) Clinical 95.9; Functional 86.8	Dislocation 2 (8.0%)
Rahman et al., 2014	14	66 (51–84)	72 months	13/14 (92.9%)	Oxford Knee Score (mean improvement) 20.1 points	Peri-prosthetic fracture 1
Sewell et al., 2012	11	57 years (41–79)	7 years (3–11.5)	1 revision required	KSS mean score Clinical: 68 Function: 50	Aseptic loosening 1 Peri-prosthetic fracture 1
Yang et al., 2012	50	Median 72 (59–82)	15 years (10–18)	15 year survival: 87%	KSS mean score Clinical: 73 Function: 47	Deep infection 7 (14%)

also be reported as a percentage of normal (normal = 100%). The mean MSTS score of the six articles was 79% of normal (SD = 7.8), with a range, reported in four of the articles, of 10–100%. In detailed breakdown of the scores in the case series by Matsumine et al. and Nakamura et al. there was greater improvement for pain than for function [22,26]. Mavrogenis et al. reported that patients' function in the MSTS 'gradually improved' in the course of follow-up [23]. It seems this is similar to what was noted in non-tumor patients: pre-operatively, patients should be counseled that functional improvement may not be as great as reduction in pain, and it may take longer to become apparent.

3.2.3. Failures

The causes of failure in tumor patients were listed in all ten of the articles were reviewed (Table 4). Infection was the most common reason for failure of the prosthesis in patients with tumors of the bone. It was cited in nine of the ten articles. Information on the mean time-to-failure for each complication was included in just one article [27]. In this study, the mean time-to-failure from infection was 3.1 years, with 4.3 years for failure attributed to aseptic loosening. There are specific reasons, mentioned below, why the risk of infection is heightened in all patients who have the rotating-hinge prosthesis implanted. Unique to patients who

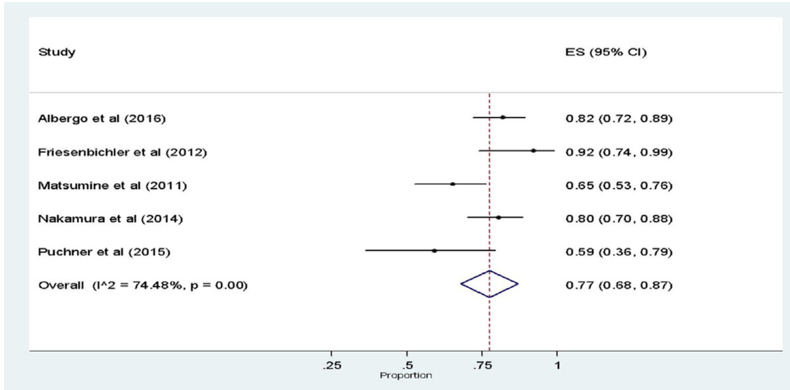

Fig. 5. Short-term (0–5 year) prosthesis survival in tumour indication cases; 77% (95% CI, 68–87%) of prostheses survived after 1–5 years follow-up.

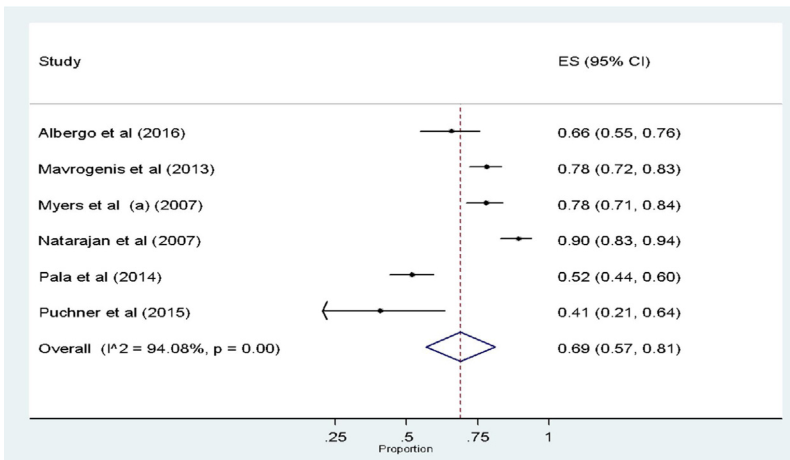

Fig. 6. Forest plot for mid term (6–10 year) prosthesis survival in tumour indication cases; 69% (95% CI, 57–81%) of prostheses survived after 6–10 years follow-up.

Table 2
Common causes of prosthesis failure in non-tumour studies with *n* = the number of articles which included information on time-to-failure for specific cause.

Causes of failure	*n* (% of total failures)	Time-to-failure (years)
Infection	23 (31.5)	4.15
Aseptic loosening	13 (17.8)	4.06
Dislocation	13 (17.8)	0.98
Periprosthetic fracture	8 (11.0)	0.79
Rotation failure	5 (6.8)	N/A
Other	11 (15.1)	N/A

receive the prosthesis with a malignant bone tumor is the adjuvant therapy–chemotherapy and radiotherapy - which leaves patients in an immunocompromised condition. Recurrence of the tumour is another concern in this group, which distinguishes the patterns of failure in tumor patients from non-tumor patients.

4. Discussion

This review summarises the current data on the rotating-hinge prosthesis in a primary setting. Several articles have drawn attention to our incomplete knowledge in this area [11,12]. Baker et al. performed a review of the literature and identified ten articles on the implant in a primary setting [11]. Their conclusion was that the rotating-hinge prosthesis is a 'viable alternative' given the correct indications. Our review has identified some more recently published articles and divided the articles based on the indication for surgery.

Eleven articles assessing 1425 non-tumour prostheses and ten articles assessing 1101 tumour-related prostheses were included for review. We noted the rate of survival of the prostheses in patients with non-tumour indications was 92% (95% CI, 87–98%) at one to five years follow-up. It is worth noting that the reported figures often do not account for patients who were lost to follow-up. Some articles include patients lost to follow-up as failure in a separate calculation ('worst case scenario'), whereas others exclude them altogether. It has been suggested that articles should adopt the former approach to reporting the survival of the prosthesis [30]. Nevertheless, there is no doubt that the rates of survival of the prosthesis have increased significantly since the introduction of the rotating-hinge design and other technical advances [23].

The scoring systems also demonstrate significant improvement in patients' pain and their function post-operatively. It is important to note that while patients had an absolute functional score inferior to their absolute pain scores, the mean improvement between the two parameters [40.2 (SD 8.3) and 39.7 (SD 21) respectively] is very similar. The degree of improvement is varied (Tables 1 and 3) but it is noticeable in all the articles. In some of the articles it is not always clear in what aspect of the patient's function an improvement has happened. The commonly used scoring systems are an aggregate of a patient's reduction in pain, functional capacity, range of movement etc. It would be beneficial if scores were disaggregated, as well as reported as an aggregate. This would help to establish a better understanding of the exact nature of the benefits of the prosthesis. It would also allow for more accurate pre-operative counselling of patients.

Table 3
Summary of studies of the rotating-hinge knee prosthesis for indication of tumor.

Authors	N° of rotating-hinge prostheses	Mean age (range)	Mean length of follow-up (range)	Survival	Function	Causes of Failure
Albergo et al., 2016	88	26	9.5 years (2–24)	10 years: 66% 5 years: 82%	MSTS Mean 26.6 points	Infection 4 (4.5%) Aseptic Loosening 5 (5.7%) Recurrence 6 (6.8%)
Friesenbichler et al., 2012	25	61.5 years	38 months (11–67)	90.9% at follow-up	KSS Clinical: 86.5 Functional: 65	Aseptic Loosening 3 Fracture 1 (4%) Dislocation 1 (4%)
Matsumine et al., 2011	69	48 (Range, 10–79 years)	57 months (6–134 months)	5-year: 85%	MSTS Mean: 20.5 points (Range 3–30 points)	Recurrence 10 (14.4%) Deep Infection 7 (10%) Aseptic loosening 4 (5.8%) Stem breakage 4 (5.8%) Displacement of shaft cap 3 (4.3%) Wear of rotation sleeve 1(1.4%)
Mavrogenis et al., 2013	225 (60 rotating-hinge prostheses)	27 (range 9–76)	31 months	10 years: 78%	MSTS Mean: 24 points	Infection 5 (8.3%) Aseptic loosening 3 (5%) Breakage of prosthesis 1 (1.6%)
Myers et al., 2007a	173	Median age 29 (Interquartile range 18–52)	12 years (5–30)	22% risk of revision at 10 years	Not included in article	Local recurrence 6% Infection 4.5% Fracture of implant 6 (3.5%) Rebushing 10 (5.8%)
Myers et al., 2007b	99	Median age 21.5 (10–74)	14.7 years (5–29)	30% risk of failure at 15 years	Not included in article	Fracture of implant 7 (7%) Infection 3(3%)
Nakamura et al., 2014	82	32 years	61 months	5 year: 80%	MSTS Mean: 21.8 points	Stem breakage 5 (6%) Infection 3 (4%) Aseptic loosening 3 (4%) Breakage of tibial tray 1(1%) Displacement of shaft cap 1(1%)
Natarajan et al., 2007	143	30.8	5.4 years	10 year: 89.8%	Enneking criteria Excellent 62% Good 27% Fair 5.5% Poor 5.5%	Periprosthetic fracture 8.3% Infection 3.5% Aseptic loosening 2.8%
Pala et al., 2014	175	32 years (Range 9–81 years)	3.1 years	8 years: 52%	MSTS II Score Mean: 25.3 points	Infection 20 (11.4%) Soft tissue failure 18 (10.3%) Tumor recurrence 11 (6.3%) Aseptic loosening 9 (5.1%)
Puchner et al., 2015	22	29 years	139 months (1–359)	1 year: 83% 5 year: 59% 10 year: 40%	MSTS Score Mean: 24.6 points	Infection 10 (45.45%) Aseptic Loosening 10 (45.45%) Tumour Recurrence 3 (13.6%)

MSTS is Musculoskeletal Tumor Society; KSSisKnee Society Score.

Table 4
Common causes of prosthesis failure in tumour studies.

Causes of failure	n (% of total failures)
Infection	65 (37.6)
Aseptic loosening	41(23.7)
Tumour recurrence	40 (23.1)
Fracture	26 (15)
Dislocation	1 (0.6)

Table 5
Modes of failure [28].

Type 1: Soft tissue failure
Type 2: Aseptic loosening
Type 3: Structural failures e.g. prosthetic, periprosthetic fracture
Type 4: Infection
Type 5: Tumour progression

Evidence has recently been emerging that many of the failures of the rotating-hinge prosthesis may not be due to the implant itself. A recent article proposed a system for categorising modes of failure for all types of endoprostheses[31]. The five proposed modes of failure are presented in Table 5. Types 1–3 are further sub-classified as mechanical failures, whereas types 4 and 5 are sub-classified as non-mechanical failures. The improved rates of survival of the hinge prosthesis are partly attributable to the fall in the incidence of aseptic loosening of the prosthesis, or type 2 failures [2,23]; as we already mentioned, this is largely due to the switch to a rotating-hinge prosthesis from a fixed-hinge prosthesis.

The most common reason for failure in our review was infection, a non-mechanical failure. Several articles have noted that there are reasons why infection is more likely to occur in patients when a rotating-hinge prosthesis is implanted [22,31]; there is often extensive soft tissue dissection, longer duration of surgeries (particularly with mega-prosthesis), and frequent immune suppression. These factors put the patients at greater risk of infection. Smith et al. adopted the system of failure outlined above and showed that, in a large study of the rotating-hinge prosthesis in a revision setting, over half of all failures were for non-mechanical reasons [32]. The authors went on to note that the rotating-hinge prosthesis is well designed and has ‘acceptable survivorship rates’. Our review supports these findings by showing that non-mechanical modes of failure are most common in the primary setting also.

It is relevant to note that recent studies have highlighted that the complexity of these complications should still not be underestimated and can still include a significant number of mechanical as well as structural modes of failure. For instance, the incidence of complications in Kearns et al. was 38.7%, which comprised of periprosthetic fracture, infection, and extensor mechanism failure–aseptic loosening was quite rare [33]. The low revision rate of aseptic loosening was also observed by Cottino et al., who saw a 10-year cumulative incidence of revision of 4.5%. They theorize that this improvement in revision outcomes is aided by the "greater use of metaphyseal fixation" [34]. Interestingly, Farid et al. noted that "complications were the rule rather than the exception in revisions" and insightfully pointed out that indications for surgery and patients' characteristics may help to explain for the differences in complication rates and outcomes [35]. So while rotating-hinge prosthesis is a significant tool under the knee surgeon's repertoire–especially in cases of major soft tissue and bone loss whereby rotating-hinge TKA would be the preferred procedure over standard TKA–it is vital to place them in the context of potential complications so as to optimize indications for surgery and manage patient expectations.

While comparisons to other studies must be made with caution, the survival rates and causes of failure in the more 'standard' primary TKA were considered. In 2017, a group conducted a review of published annual reports of National Joint Registries from Australia, New Zealand, Sweden and the UK to assess factors relating to revision rate in TKA [36]. The review included data from primary surgeries for any indication using any type of TKA. At 13 years follow-up, they found a cumulative revision rate of 14.9% (95% CI, 13.7–16.3%) in those under the age of 55, and 3.1% (95% CI, 2.9–3.4%) in those older than 75. While direct comparisons cannot be made, the revision rates from the long-term (11–15 year) follow-up of the non-tumour rotating-hinge TKAs in this review [12% (95% CI, 6-21%) across an age range of 21–99 years] fall within this range. When consideration is given to both the severity of indications for primary rotating-hinge TKA and the impact the procedure has on the structure of the knee, these survival results appear to compare favourably with those from National Joint Registries.

A 2014 study, retrospectively reviewed the rates and causes of failure in 11,816 TKAs of varying prostheses used for osteoarthritis, with a maximum follow-up of 18 years [37]. Of the 256 revisions (2.2% failure rate), 44% were due to polyethylene wear, with an average time-to-failure from this cause of 8.1 years. Other common causes of failure included infection (38.7%) and loosening (12.1%). Polyethylene wear was not a commonly cited cause of failure in the articles included in our review. This may partly be due to advancements in the design of rotating-hinge prostheses, which now frequently incorporate metallic tibial baseplates that reduce polyethylene wear. Furthermore, revision surgery of a rotating-hinge prosthesis is a more technically complex procedure compared to a more standard primary TKA. Due to greater experience required, and fewer remaining options for future prosthesis, the surgeon will have more reluctance when considering revision of a rotating-hinge TKA.

There are limitations to this review. The studies were mostly retrospective, which have well known limitations. The study populations varied between the different papers, which makes comparisons between their results more difficult. The designs of the rotating-hinge (mega-prosthesis or not) were not distinguished. This is an important factor due to the different levels of stress they have on the non-impact interface. There is also variation in the length of follow-up in the different articles so the figures for survival of the prosthesis have to be compared carefully.

5. Conclusion

In conclusion, the rotating-hinge prosthesis has favorable outcomes for patients. Its rate of survival is now acceptable especially when it is used in patients for non-tumor indications. The various scoring systems have shown consistent and significant improvements in patients' pain and function. The most common reason for failure of the prosthesis is infection. However, recent studies have shown that mechanical and structural modes of complication still warrant attention, and so indications for rotating-hinge TKA must be very well selected and limited. Further research on the prosthesis is required. Future studies could adopt a 'worst-case scenario' survival rate, report scoring systems in a more detailed fashion, and divide causes of failure into mechanical and non-mechanical modes.

Disclosure of interest

The authors declare that they have no competing interest.

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Authors' contribution

Ali Abdulkarim: for topic selection, study design, statistical analysis, writing, and editing.
Lachlan Glen and Anna Keane: for research, writing, and statistical analysis.
Shu Yang Hu: for writing and editing.
Dermot Murphy: for writing and editing.

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