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The Impact of Polyethylene Thickness on the Fate of Primary Total Knee Arthroplasty

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Abstract

Purpose: The aim of the present systematic review was to determine the impact of Polyethylene thickness on the fate of primary total knee arthroplasty and to provide recommendations based on this evidence.

Methods: Five literature databases published between 2000 to 1st April 2021 were searched using three key search phrases (''Failure Rates'', ''Polyethylene thickness'' and ''primary total knee arthroplasty'').

Results: The difference between thin and thick liners in ΔROM was not significant. Thicker polyethylene may effect on the rate of revision surgery. factors that lead to thicker bearings such as deeper tibial bone removal and ligament imbalance may be effective in increasing failure. The result of Knee Society clinical scores is the same in thick and thin Polyethylene cases.

Conclusion: The results of this study indicate that the thickness of polyethylene in TKA has no effect on Knee Society clinical scores and knee range of motion (ROM) but the thickness of polyethylene may effect on the rate of revision surgery. The lower thickness of polyethylene is associated with better pre operation planning and the surgeon's skill in implementing better surgical techniques and the lower thickness of polyethylene may decrease the rate of revision surgery.

Keywords: Failure Rates; Polyethylene thickness; Primary total knee arthroplasty; Gap space

Introduction

Total knee arthroplasty (TKA) is the most effective treatment for symptomatic cartilage wear and end-stage, symptomatic osteoarthritis of the knee. TKA is a common procedure with good implant survivorship and functional results [1]. Optimal results depend on proper bone cuts and soft tissue balancing during surgery. The amount of bone removal and the extent of soft tissue releasing are effective at the gap expansion. It is important to achieve a balance between bone resection, soft tissue laxity, and adequate polyethylene thickness [2]. However, improper polyethylene size selection has been proposed to predispose patients to postoperative stiffness or instability following TKA [3]. Aseptic loosening due to osteolysis and polyethylene wear is one of the most common cases of failure that requires revision surgery following total knee arthroplasty [4]. Improvements in ultra-high molecular weight polyethylene sterilization and cross-linking properties have improved wear and fatigue failure characteristics of these bearings to prevent these complications. Historically, however, these failure mechanisms have been associated with thin polyethylene bearings, forcing manufacturers to produce bearings with a minimum polymer thickness of 8 mm [5-7].

Materials and Methods

Literature and database searches

Google Scholar, Cochrane library, Medline, Embase and PubMed databases were searched using a combination of three keywords ''Failure Rates'', ''Polyethylene thickness'' and ''primary total knee arthroplasty''. References of studies that met inclusion criteria were additionally considered.

Literature Selection

Two reviewers assessed studies against the inclusion criteria first by examination of title, abstract, and then the full text. When it was unclear from the abstract whether the paper met inclusion criteria, the entire paper was included in the study. If still unclear our senior authors were consulted. Inclusion criteria were:

- The study focused on primary TKA.
- The article considered unilateral or bilateral primary TKA.
- The study had been published between 2000 to 1st April 2021.
- The study analyzed association between "Failure Rates" and "TKA polyethylene thickness".
- English language

Data extraction

For each paper meeting inclusion criteria, the full reference, type of study, sample size and postoperative follow-up duration were extracted, along with core information summarizing key findings from each paper. Two reviewers each categorized finding and these were summarized and tabulated. Figure 1 shows flowchart for article selection. Studies and their findings related to the impact of Polyethylene thickness on the fate of TKA are summarized in table 1.

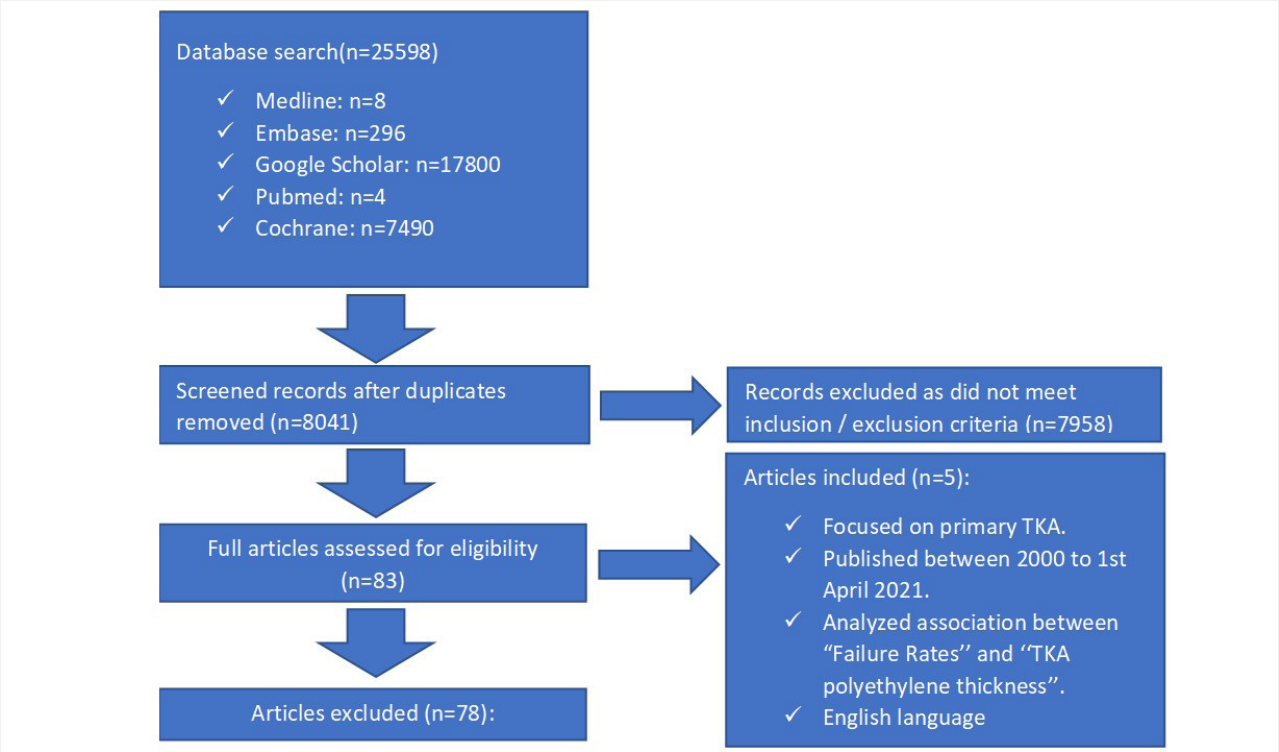

Figure 1: Flowchart for article selection.

Table 1: Studies and their findings related to the impact of Polyethylene thickness on the fate of TKA.

	Authors	Year	Journal	Conclusion
1	Simon P. Garceau et al.	2020	The Journal of Arthroplasty	Both rates of revision surgery and clinical outcomes are similar for TKAs performed with thick and thin liners. Preoperative factors are likely to play an important role in liner thickness selection, and emphasis should be placed on ensuring sound surgical technique [8].
2	Michael E. Berend et al.	2010	The Journal of Arthroplasty	Thicker bearings did not directly cause failure factors that lead to the insertion of a thicker bearing such as a deeper tibial resection and ligament imbalance can cause increased failure [9].
3	Nicholas J. Greco et al.	2018	The Journal of Arthroplasty	Patients with thick polyethylene bearings performed similarly or better in multiple clinical outcomes and survivorship compared to those with thin bearings [4].
4	James E. Feng et al.	2019	The Journal of Knee Surgery	Polyethylene liner thickness alone is not a predictor of postoperative knee stiffness necessitating manipulation under anesthesia [10].
5	Jan Victor et al.	2014	International Orthopaedics (SICOT)	At a follow up minimum of 15 years, there are highest revision rate among patients with prosthesis of Genesis I in the younger age group and with insert thickness >11 mm [11].

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Results

Range of Motion (ROM)

James E. Feng et al. noticed in total, 2,764 patients were evaluated, of which 71 (2.57%) underwent manipulation under anesthesia (MUA). When aggregated together to compare the manipulation under anesthesia rate between the thinnest liner and the next two sizes, no statistically significant difference was observed (p=1) [8]. Simon P. Garceau et al noticed in 195 patients having undergone bilateral primary TKA (simultaneous: 23% and staged: 77%) no significant difference was noted between thin (11.1º ± 16.9) and thick (10.0º ± 17.5) liners in ΔROM (P = .66) [9].

Need to TKA Revision

Michael E. Berend et al noticed in 670 primary TKAs with a single implant design the failure rate in knees with bearings 14 mm or less was 0.7%, whereas the failure rate of knees with bearings 16 mm or greater was 2.3% (P=.0001; hazard ratio, 3.2). No knee was revised for polyethylene wear. Thicker bearings did not directly cause failure, but factors that lead to the insertion of a thicker bearing such as a deeper tibial resection and ligament imbalance may contribute to the observed increased failure [10]. Simon P. Garceau et al. [9] noticed in 195 patients having undergone bilateral primary TKA (simultaneous: 23% and staged: 77%) Comparison of cohorts for all-cause aseptic revision did not demonstrate any significant difference between the thin (4.1%) and thick (3.1%) cohorts (P = .59). Jan Victor et al. [11] noticed in 245 consecutives primary TKA (consisted of 156 Genesis I knees and 89 Genesis II knees) Overall Kaplan-Meier cumulative survivorship was 92.4 % at 15.7 years. Survivorship in the Genesis I group was 90.1% at 15.5 years and in Genesis II 98.1% at 15.0 years. The difference was not statistically significant (p =0.077). Analysis of different insert size groups revealed significantly worse implant survival with PE thickness >11 mm (56.7 % at 14.0 years), compared with PE thickness ≤11 mm (97.1 % at 15.9 years) (p <0.0001). The OR for revision of a PE insert >11 mm was 35.3 [11].

Knee Society clinical scores

Complete assessment of functional outcome scores was available for 100 persons of 195 patients of Simon P. Garceau et al and demonstrated similar ΔKSS in the thin (51.4 ± 11.5) vs thick (51.6 ± 11.4) cohorts (P = .86) [9]. Jan Victor et al. [11] showed in 245 consecutives primary TKA (consisted of 156 Genesis I knees and 89 Genesis II knees) there was no difference in clinical (KOOS) or radiographic outcome between 2 groups (with considering the thickness of polyethylene).

Discussion

There are several factors that lead to limited mobility following TKA and will require manipulation under anesthesia (MUA). In a study by James E. Feng and et al, it was shown that the thickness of polyethylene had no effect on limiting short-term range of motion after knee replacement surgery. Therefore, the amount of tibial bone removal does not seem to be a factor in MUA in this large retrospective study [1,8]. One of the common mechanisms in adverse outcomes following TKA is instability, which can be due to improper ligament balancing following arthroplasty. In general, ligament balance is assessed by the surgeon's mind and eye and can be corrected by varying the thickness of the polyethylene and soft tissue releasing. If the thickness of polyethylene is selected inappropriately, more or less, it can cause changes in movement properties, contact pressure and wear of polyethylene and prosthesis [12,13].

According to the studies of El-Deen et al. [14], Pijls et al and Naudie et al, in the thickness of polyethylene less than 8 mm, and especially less than 6 mm, the contact pressure increases more and more [6,7,14]. However, Petty et al. Stated that increasing the thickness of polyethylene reduces contact stress and makes it less sensitive to further increasing the thickness of polyethylene [10,15].

One of the goals of surgery is to remove a minimal amount of tibia and femur, followed by restoring the joint surface to a suitable location. However, research shows that below the tibia plateau, the strength of the tibia is almost constant to a depth of 20 mm, allowing surgeons to remove thicker sections of the tibia without compromising tibia strength. However, revision surgery of the TKA poses more difficulties such as bone loss and the need for a block to replace the over-harvested bone [13,16].

Study of Garceau et al. [9] showed that both the rate of revision surgery and the clinical outcome were similar for TKAs performed with different thicknesses of polyethylene. Preoperative factors and the surgeon's skill probably play an important role in choosing the thickness of polyethylene and the correct surgical method should be emphasized. Cadaveric studies have shown that further proximal removal of the tibia increases the amount of strain of the bone beneath the tibia. In an in vitro biomechanical study, by removing a thickness of more than 10 mm from the tibia, a significant increase in shear pressure was observed in the anterior and posterior regions of the tibia. The resulting loading pattern in the peripheral tibia can lead to muscle fatigue through repetitive overload, especially in the internal area. It is possible that more pressure in the peripheral areas of the tibia will lead to increased edge loading in weak areas of the tibia, and these factors together provide the basis for failure [10,16]. Many studies have shown that high pressure can increase the rate of failure due to the collapse of cancellous bone and loose prostheses. El-Deen et al. [14] have suggested that thicker polyethylene be avoided if possible because, despite the unnecessary removal of the tibia, there is no advantage in assessing contact forces in these cases.

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This study is associated with several limitations. First, the number of related articles is small. Second, in all these articles, the size difference of 4 mm polyethylene has been considered. If this size difference is more than 4 mm, there may be a significance difference was achieved between the two groups. The follow-up of these studies is not long-term, so it is not possible to assess the need for revision of TKA, especially with different Polyethylene thickness.

Conclusion

The results of this study indicate that the thickness of polyethylene in TKA has no effect on Knee Society clinical scores and knee range of motion (ROM) but the thickness of polyethylene may effect on the rate of revision surgery. The lower thickness of polyethylene is associated with better pre operation planning and the surgeon's skill in implementing better surgical techniques and the lower thickness of polyethylene may decrease the rate of revision surgery.

Conflicts of Interest

None.

References

1. McCalden RW, MacDonald SJ, Bourne RB, Marr JT (2009) A Randomized Controlled Trial Comparing "High-Flex" vs "Standard" Posterior Cruciate Substituting Polyethylene Tibial Inserts in Total Knee Arthroplasty. J Arthroplasty 24(6 Suppl): 33–38.
2. Seo JG, Lee BH, Moon YW, Chang MJ (2014) Soft tissue laxity should be considered to achieve a constant polyethylene thickness during total knee arthroplasty. Arch Orthop Trauma Surg 134(9): 1317–1323.
3. Peersman G, Slane J, Dirckx M, Vandevyver A, Dworschak P, et al. (2017) The influence of polyethylene bearing thickness on the tibiofemoral kinematics of a bicruciate retaining total knee arthroplasty. Knee 24(4): 751–760.
4. Greco NJ, Crawford DA, Berend KR, Adams JB, Lombardi A V (2018) "Thicker" Polyethylene Bearings Are Not Associated with Higher Failure Rates in Primary Total Knee Arthroplasty. J Arthroplasty. 33(9): 2810–2814.
5. Weber AB, Morris HG (1996) Thickness of tibial inserts in total knee arthroplasty. J Arthroplasty. 11(7): 856–858.
6. Pijls BG, Van Der Linden-Van Der Zwaag HMJ, Nelissen RGHH (2012) Polyethylene thickness is a risk factor for wear necessitating insert exchange. Int Orthop 36(6): 1175–1180.
7. Naudie DDR, Ammeen DJ, Engh GA, Rorabeck CH (2007) Wear and osteolysis around total knee arthroplasty. J Am Acad Orthop Surg 15(1): 53–64.
8. Feng JE, Anoushiravani AA, Ziegler J, Schwarzkopf R, Long WJ (2019) Manipulation under Anesthesia: Does Polyethylene Thickness Matter? J Knee Surg 32(11): 1088–1093.
9. Garceau SP, Warschawski YS, Tang A, Sanders EB, Schwarzkopf RM, et al. (2020) The Effect of Polyethylene Liner Thickness on Patient Outcomes and Failure After Primary Total Knee Arthroplasty. J Arthroplasty 35(8): 2072–2075.
10. Berend ME, Davis PJ, Ritter MA, Keating EM, Faris PM, et al. (2010) "Thicker" Polyethylene Bearings Are Associated with Higher Failure Rates in Primary Total Knee Arthroplasty. J Arthroplasty 25(6): 17–20.
11. Victor J, Ghijselings S, Tajdar F, Van Damme G, Deprez P, et al. (2014) Total knee arthroplasty at 15-17 years: Does implant design affect outcome? Int Orthop 38(2): 235–241.
12. Abolghasemian M, Samiezadeh S, Sternheim A, Bougherara H, Barnes CL, et al. (2014) Effect of patellar thickness on knee flexion in total knee arthroplasty: A biomechanical and experimental study. J Arthroplasty 29(1): 80–84.
13. Li Z, Esposito CI, Koch CN, Lee Y yu, Padgett DE, et al. (2017) Polyethylene Damage Increases with Varus Implant Alignment in Posterior-stabilized and Constrained Condylar Knee Arthroplasty. Clin Orthop Relat Res 475(12): 2981–2991.
14. El-Deen M, Garcia-Finana M, Jin ZM (2006) Effect of ultra-high molecular weight polyethylene thickness on contact mechanics in total knee replacement. Proc Inst Mech Eng Part H J Eng Med 220(7): 733–742.
15. Shi JF, Wang CJ, Berryman F, Hart W (2008) The effect of polyethylene thickness in fixed- and mobile-bearing total knee replacements. Proc Inst Mech Eng Part H J Eng Med 222(5): 657–667.
16. Berend ME, Ritter MA, Meding JB, Faris PM, Keating EM, et al. (2004) Tibial component failure mechanisms in total knee arthroplasty. Clin Orthop Relat Res (428): 26–34.

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