

Clinical and Patient Reported Outcomes of Vitamin E Diffused Highly Cross-Linked Polyethylene Liner Versus Moderately Cross-Linked Polyethylene Liner in Total Hip Arthroplasty: A Meta-Analysis



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ABSTRACT

Introduction In the modern era of Medicine, total hip arthroplasty (THA) is found to last longer than ever before due to the fact that there has been improved bearing surfaces and materials available. Despite these modern approaches, failure caused by polyethylene wear, aseptic loosening, instability and mispositioning and even infection could affect THA survival. In the course of addressing anti-wear characteristics of the conventional polyethylene surface various approaches have been made. To date, there are very limited studies done in which polyethylene liner is better.

General Objective To compare the effects of vitamin E diffused highly cross-linked polyethylene liner versus moderately cross-linked polyethylene liner in THA.

Methodology Meta-analysis research design was used in this study. The primary investigators conducted a comprehensive literature search from Medline, Cochrane Library, PubMed, Elsevier, Google Scholar, Embase and ClinicalTrial.gov as electronic database. All randomized controlled trials comparing the effects of vitamin E diffused highly cross-linked polyethylene liner versus moderately cross-linked polyethylene liner in THA were included in the review.

Conclusions The investigation disclosed no statistical significance between moderately cross-linked polyethylene liner and vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on mediolateral, longitudinal and anteroposterior axes after 2 and 5 years of undergoing THA. Moreover, the data pertaining to patient reported outcomes and clinical outcomes measure also indicated no statistical significance between moderately cross-linked polyethylene liner and vitamin E diffused highly cross-linked polyethylene liner. This indicates that vitamin E diffused highly cross-linked polyethylene liner is comparable with the conventional moderately cross-linked polyethylene liner. Vitamin E-infused highly cross-linked polyethylene (VEPE) showed an almost similar stability with regard to the wear rates and the component showed similar stability with that of moderately cross-linked polyethylene liner.

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INTRODUCTION

Osteoarthritis (OA), often referred to as 'wear-and-tear' arthritis, age-related arthritis, or degenerative joint disease, is the most common form of joint disorder.[1] The hip joint is one of the body's largest weight-bearing joints, only secondary to the knee joint, and is commonly affected by OA.[2]

In USA, the prevalence of symptomatic hip OA was reported at 9.2% among adults aged 45 years and older, with 27% showing radiologic signs of disease; prevalence was slightly higher among women.[3] Caucasian populations also have a higher hip OA prevalence that ranges between 3% and 6% as compared with 1% or less in Asians, blacks, East Indians or native Americans.[4] According to the Centers for Disease Control and Prevention, a lifetime risk for symptomatic hip OA is 18.5% for men and 28.6% for women.[5]

OA is a chronic disorder affecting synovial joints although sometimes referred to as 'degenerative joint disease'. It is characterized by loss of structural integrity of cartilage lining the articular surface. Destructive processes lead to swelling, decreased shock absorbing properties (compliance), softening, fracturing, fibrillation, ulceration and ultimately erosion of the cartilage with exposure of the subchondral bone (eburnation). From this point onwards in the disease process, forces are transmitted to the subchondral bone leading to increased bone turnover with sclerosis and the formation of cysts and osteophytes. The bone overlying the cysts or areas of avascular necrosis might collapse causing flattening of the femoral head—a characteristic appearance in advanced OA.[6]

The most common symptom of hip OA is pain around the hip joint (generally located in the groin area). The pain can develop slowly and worsen over time (most common) or can have a sudden onset. Pain and stiffness can develop in the morning or after sitting or resting. Stiffness typically lasts for only a few minutes and subsides over 30 or fewer minutes. Movement and activity that loosen the joint generally improve OA symptoms.[6]

The treatment for hip OA ranges from conservative therapy to surgical management.[7] Conservative therapies would include anti-inflammatory drugs, NSAIDs, intra-articular injections of corticosteroids; hyaluronic acids; and, relatively recently, platelet-rich plasma injection.[8] On the other hand, operative management would include THA.[9] THA is today's surgical modality for patients with intractable pain, for those who have failed nonsurgical treatment, and for those with severe functional impairment. Hip implant longevity has been demonstrated with as many as 95% of prostheses remaining functional and having good overall general physical health, ability to exercise, remaining active and maintaining a good weight for which more than 80% of prostheses can remain functional at 25 years. However, some reported that the most common reason for revision surgery following conventional THA is aseptic loosening. To address this complication, a highly cross-linked polyethylene (HXLPE) was developed in 1990s. However, oxidative embrittlement of the polymer was also reported in some studies.[6] Thus VEPE has been developed with the aim of further improving mechanical properties and clinical performance of existing moderately and highly cross-linked polyethylene (ModXLPE/HXLPE).

By cross-linking ultra-high molecular weight polyethylene with radiation, wear characteristics are substantially improved and modern highly cross-linked polyethylene (HXLPE) is produced.[10] The drawback of this treatment is free radicals emerging from the cascade reaction triggered by the cross-linking irradiation. These will deteriorate the mechanical properties of polyethylene by oxidative degradation. VEPE was developed to reduce wear and embrittlement, by improving the oxidative stability of HXLPE.[11] This makes it possible to fully conserve improved wear characteristics through cross-linking because annealing or remelting is no longer necessary to eliminate free radicals and thus produce oxidative stability of polyethylene.[12]

The revision rate of THA was found to have grown steadily in recent years. The usual causes of revision were loosening, dislocation, instability and presence of wear and infection. The development of PE manufacturing has led to reduced rate of revision for THA. Cases of PE wear encountered on patients had led to the development of highly cross-

linked PE. The addition of vitamin E to this could give protection against oxidation and may promote low wear rates. Moreover, addition of vitamin E could lead to reduced inflammatory reaction to the particles associated with wear.[13]

One of the most common reasons for revision surgery following conventional THA reported is aseptic loosening. This is due to free radicals trapped in crystalline regions and could lead to oxidative embrittlement of the liner. Previous studies have demonstrated the safety and efficacy of VEPE. Therefore, researches that focused on the effects of vitamin E incorporation in polyethylene liner used in THA are becoming the focus in the field of research. However, to our knowledge, there were no published systematic reviews that compared the effects of vitamin E incorporation in polyethylene liner versus moderate cross-linked polyethylene liner in THA.

The main objective of this study is to compare the effects of vitamin E diffused highly cross-linked polyethylene liner versus moderately cross-linked polyethylene liner in THA in terms of Incidence of Migration, Head Penetration and Wear by Radioisometric Analysis (RSA) and Patient and Clinical reported Outcomes namely VAS Score, Harris Hip Score (HHS), EuroQoL five-dimension three-level (EQ-5D) and University of California, Los Angeles (UCLA) activity score.

METHODOLOGY

Search Strategy

The literature search was conducted using Medline, Cochrane Library, PubMed, Elsevier, Google scholar, Embase and ClinicalTrial.gov as the electronic database. All identified clinical trials published from April 2011 up to April 2021 that studied the effects of vitamin E incorporation in polyethylene liner versus moderate cross-linked polyethylene liner in THA was reviewed individually. The citations were identified with the use of a combination of the following text words: "Vitamin E Polyethylene Liner", "Cross-linked polyethylene liner", "total hip arthroplasty" and "randomized". All trials that matched the terms set by the researchers were retrieved. Titles and research abstract were reviewed individually. No restrictions for geography or location were applied. However, restriction on English language was applied.

Eligibility Criteria

Type of Study

The present systematic review only included randomized controlled trials comparing the effects of vitamin E diffused highly cross-linked polyethylene liner versus moderately cross-linked polyethylene liner in THA. Case reports, cross-sectional and cohort studies were excluded.

Participants

All patients diagnosed with primary or secondary osteoarthritis and who underwent THA using polyethylene liner.

Types of Intervention

Outcomes of vitamin E diffused highly cross-linked polyethylene liner will be compared to moderately cross-linked polyethylene liner in THA.

Outcome

- Harris Hip Score (HHS)
- EuroQoL five-dimension three-level (EQ-5D) to assess general health.
- University of California, Los Angeles (UCLA) activity score

DATA COLLECTION AND ANALYSIS

Selection of Studies

The authors independently reviewed articles from the literature search to be included in the study. Thorough screening for the titles and abstracts related to the above-mentioned keywords was done. If the research titles or abstracts were debatable, the reviewer retrieved the full copy of the study to evaluate it further. Discussion and consensus were done to solve any disagreement among reviewers. Trials that failed to meet the inclusion criteria were excluded. Also, duplicated copies of studies were reviewed and subjected to exclusion if proven duplicated.

Four randomized controlled trials (RCTs) were included in this study. Table 1 shows the characteristics of all the RCTs included in this study.

Table 1 Characteristics of Randomized Controlled Trial Studies

Studies	Country	Number of Patients		Age		Sex Male/ Female		Follow-Up
		MxLPE	VEPE	MxLPE	VEPE	MxLPE	VEPE	
Galea, et al., (2019)	US	34	39	62.6±8.3	66.1±6.5	20/14	22/17	2 & 5 years
Salemyr et al., (2015)	Sweden	26	25	62±5	62±6	11/15	11/14	2 years
Skoldenberg et al., (2015)	Sweden	21	21	67±5	67±4	11/10	10/11	2 years
Thoen et al., (2020)	Norway	37	31	61 (34-80)	58 (27-78)	16/15	20/17	2 and 5 years

MxLPE - Moderately Crosslinked Polyethylene Liner; VEPE - Vitamin E Diffused Polyethylene Liner;

Data Extraction

Data extracted was organized on a standardized data sheet. Data extracted included primary author, year of publication, place where the study was conducted, total number of participants, study blinding, allocation concealment, assignment of participants, and grouping studies. The investigator also extracted the intervention given to participants, dosage, duration of treatment, outcome measures, as well as treatment failure reported in the RCTs. The researchers resolved any disagreement by discussion and consensus.

Assessment of Heterogeneity

The investigators identified heterogeneity by visual inspection of the Forrest plot and more importantly by statistical analysis of variance using the Chi-squared test based from the Cochrane handbook. The investigators used the guide recommended by the Cochrane handbook to interpret heterogeneity.

0% – 40%: Might not be important

30% - 60%: May represent moderate heterogeneity

50% - 90%: May represent substantial heterogeneity

75% - 100%: Considerable heterogeneity

The importance of the observed value of I^2 depended on the magnitude and direction of effects and strength of heterogeneity.

Assessment of Bias

For the methodological quality of the individual clinical trials, the Jadad Scale was used, which was based on the three following subscales: randomization (2, 1 or 0), blinding (2, 1 or 0)

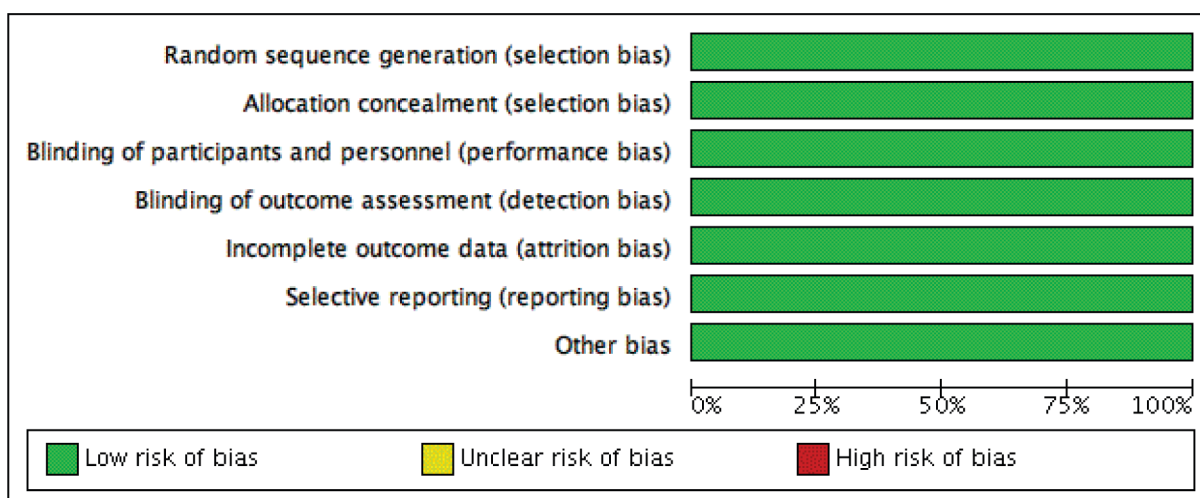
and dropouts/withdrawals (1 or 0). Guidelines for Cochrane collaboration were used to assess the risk bias. The researcher evaluated methods of random sequence generation and allocation concealment for the selection bias. The methods of blinding among participants and investigator of each trial were noted for the performance bias, while blinding for the outcome assessment was used to calculate detection bias. Completeness of the outcomes data was used to evaluate attrition bias. Lastly the publication bias was only evaluated using the funnel plot.

Data Analysis

Review Manager Version 5.3 (Revman 5.3) was used by the researcher to perform the systematic review and meta-analysis of included RCTs. To test the heterogeneity among clinical trials included in the study, Chi-square tests (χ^2) and I^2 tests were performed. To independently assess the methodological quality of each clinical trial, Jadad scores were compared. Publication bias was also evaluated by visual inspection of the funnel plots and Egger's tests. Lastly, to summarize information on individual studies and give a visual suggestion of the amount of study heterogeneity and show the estimated common effect, Forest plot was used for representation.

RISK BIAS SUMMARY

The figures presented above consisted of the risk of bias graphs presenting the different studies included in this research investigation. It could be seen from the figures that there was a low risk with regard to random sequence generation allocation concealment and blinding of participants, blinding of participants and personnel, incomplete outcome data, selective



Risk of bias graph: review authors’ judgments about each risk of bias item presented as percentages across all included studies.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Galea et al., (2019)	+	+	+	+	+	+	+
Salemyr et al., (2015)	+	+	+	+	+	+	+
Sköldenberg et al., (2015)	+	+	+	+	+	+	+
Thoen et al., (2020)	+	+	+	+	+	+	+

Risk of bias summary: review authors’ judgments about each risk of bias item for each included study.

reporting and other biases. These were all observed across studies of Galea, et al., (2019); Salemyr, et al., (2015); Skoldenberg, et al., (2015) and Thoen, et al., (2020).

ETHICAL CONSIDERATION

Permission

The researcher sought permission from the

Department of Orthopaedics at the University of Santo Tomas Hospital prior to conducting the study. All maneuvers and data gathering approaches only started when permission had been granted in writing by the department concerned.

Confidentiality Issues

There were no confidentiality issues involved in the study.

Data Privacy

The author fully agreed in concordance with the Data Privacy Act of 2001, that all documents, information and materials that were obtained during the conduct of this investigation was used for exclusive interpretation of results in accordance to the declared objectives of this research paper. Any form of raw data was deleted from the storage device of the proponent’s computers, laptops, mobile phones and other electronic devices used in partial or in full for data safekeeping. In drafting the final research proposal, all data saved in these devices were deleted, put to electronic trash bin and erased completely from the devices’ memories.

Disclosure of Conflict of Interest

The author had no actual and potential financial or personal conflict of interest for this research.

RESULTS

This chapter shows the salient findings of the study. The presentation, interpretation and analysis of data are shown in this chapter.

Table 2 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on mediolateral axis after 2 years of undergoing THA. In patients under the MxLPE group, the highest mean average (0.06±0.17) was noted by Skoldenberg, et al., (2015) while the lowest mean average of -0.15±0.13 was recorded in the study of Salemyr, et al., (2015). In the VEPE group, the highest mean average of 0.05±0.22 was obtained by Thoen, et al., (2020) while the lowest mean of -0.05±0.11 was recorded by Salemyr, et al., (2015). The investigation had a pooled estimate for standard mean difference of -0.13 [95% CI -0.39-0.13]. There was no significant difference between patients under the MxLPE and VEPE when they were compared against the mediolateral axis,

Table 2 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Migration, Head Penetration and Wear on Mediolateral (X) Axis, 2 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.04	0.12	34	0.02	0.21	39	31.8%	0.11 [-0.35, 0.57]	
Salemyr et al., (2015)	-0.15	0.13	26	-0.05	0.11	25	20.5%	-0.82 [-1.39, -0.24]	
Skoldenberg et al., (2015)	0.06	0.17	21	0.02	0.21	21	18.3%	0.21 [-0.40, 0.81]	
Thoen et al., (2020)	0.03	0.07	31	0.05	0.22	37	29.5%	-0.12 [-0.59, 0.36]	
Total (95% CI)	112			122			100.0%	-0.13 [-0.39, 0.13]	
Heterogeneity: Chi ² = 7.76, df = 3 (P = 0.05); I ² = 61%									
Test for overall effect: Z = 0.97 (P = 0.33)									

Table 3 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Migration, Head Penetration and Wear on Longitudinal (Y) Axis, 2 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.03	0.21	34	0.05	0.31	39	32.1%	-0.07 [-0.53, 0.39]	
Salemyr et al., (2015)	0.09	0.15	26	0.01	0.11	25	21.5%	0.60 [0.03, 1.16]	
Skoldenberg et al., (2015)	0.11	0.22	21	0.32	0.24	21	16.7%	-0.89 [-1.53, -0.26]	
Thoen et al., (2020)	0.11	0.05	31	0.1	0.15	37	29.8%	0.09 [-0.39, 0.56]	
Total (95% CI)	112			122			100.0%	-0.02 [-0.28, 0.24]	
Heterogeneity: Chi ² = 12.11, df = 3 (P = 0.007); I ² = 75%									
Test for overall effect: Z = 0.15 (P = 0.88)									

Table 4 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Migration, Head Penetration and Wear on Anteroposterior (Z) Axis, 2 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.04	0.63	34	0.07	0.57	39	2.8%	-0.03 [-0.31, 0.25]	
Salemyr et al., (2015)	0.02	0.2	26	0.05	0.21	25	16.8%	-0.03 [-0.14, 0.08]	
Sköldenberg et al., (2015)	-0.04	0.16	21	0.02	0.21	21	16.7%	-0.06 [-0.17, 0.05]	
Thoen et al., (2020)	-0.01	0.09	31	-0.04	0.15	37	63.7%	0.03 [-0.03, 0.09]	
Total (95% CI)	112			122			100.0%	0.00 [-0.04, 0.05]	
Heterogeneity: Chi ² = 2.42, df = 3 (P = 0.49); I ² = 0%									
Test for overall effect: Z = 0.14 (P = 0.89)									

Table 5 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Migration, Head Penetration and Wear on Mediolateral (X) Axis, 5 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.06	0.29	34	0.01	0.16	39	51.9%	0.22 [-0.25, 0.68]	
Thoen et al., (2020)	0.03	0.1	31	0.07	0.21	37	48.1%	-0.23 [-0.71, 0.25]	
Total (95% CI)	65			76			100.0%	-0.00 [-0.33, 0.33]	
Heterogeneity: Chi ² = 1.75, df = 1 (P = 0.19); I ² = 43%									
Test for overall effect: Z = 0.00 (P = 1.00)									

2 years after total arthroplasty (p = 0.330 >0.05; I²=61%).

Table 3 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on longitudinal axis after 2 years of undergoing THA. In the MxLPE group, the highest mean average for migration, head penetration and wear on longitudinal axis was 0.11±0.22. This was noted by Skoldenberg, et al., (2015). This was followed by Thoen, et al., (2020) where a mean average of 0.11±0.05 was obtained. The lowest mean average for migration, head penetration and wear on longitudinal axis was 0.03±0.21. This data came from the research of Galea, et al., (2019). In the VEPE group, the highest mean average of 0.32±0.24 was reported by Skoldenberg, et al., (2015) and the lowest mean average was 0.01±0.11. This was obtained by Salemyr, et al., (2015). The results yielded a pooled estimate for standard mean difference of -0.02 [95% CI -0.28-0.24]. Statistical difference was not observed between MxLPE and VEPE groups in terms of migration, head penetration and wear on longitudinal axis 2 years after undergoing THA (p = 0.880 >0.05).

Table 4 presents the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on anteroposterior axis after 2 years of undergoing

THA. In the study involving patients provided with MxLPE, the highest mean was 0.04±0.63 as recorded by Galea, et al., (2019). On the other hand, the lowest mean average of migration, head penetration and wear on anteroposterior axis after 2 years of undergoing THA was -0.04±0.16 recorded by Skoldenberg, et al., (2015). In the VEPE group, the highest mean average of 0.07±0.57 was recorded by Galea, et al., (2019) and the lowest mean average of -0.04±0.15 was obtained by Thoen and colleagues (2020). The pooled estimate for standard mean difference was 0.00 [95% CI -0.04-0.05]. Statistical difference was seen between migration, head penetration and wear on anteroposterior axis after 2 years of undergoing THA when patients were categorized according to MxLPE and VEPE (p = 0.890 >0.050; I²=0%).

Table 5 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on mediolateral axis after 5 years of undergoing THA. In patients under the MxLPE group, a high mean average was obtained by the study of Galea, et al., where a mean average of 0.06±0.29 was obtained. The low mean average of migration, head penetration and wear on mediolateral axis 5 years post THA of 0.03±0.10 was obtained by Thoen, et al., (2020). In patients enrolled under the VEPE group, high mean average (0.07±0.21)

Table 6 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Migration, Head Penetration and Wear on Longitudinal (Y) Axis, 5 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.08	0.24	34	0.04	0.27	39	52.0%	0.15 [-0.31, 0.61]	
Thoen et al., (2020)	0.2	0.09	31	0.17	0.15	37	48.0%	0.23 [-0.24, 0.71]	
Total (95% CI)			65			76	100.0%	0.19 [-0.14, 0.52]	

Heterogeneity: Chi² = 0.06, df = 1 (P = 0.81); I² = 0%
 Test for overall effect: Z = 1.14 (P = 0.25)

Table 7 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Migration, Head Penetration and Wear on Anteroposterior Axis (Z) Axis, 5 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.09	0.19	34	0.1	0.24	39	51.9%	-0.05 [-0.51, 0.41]	
Thoen et al., (2020)	0	0.09	31	-0.02	0.13	37	48.1%	0.17 [-0.30, 0.65]	
Total (95% CI)			65			76	100.0%	0.06 [-0.27, 0.39]	

Heterogeneity: Chi² = 0.42, df = 1 (P = 0.52); I² = 0%
 Test for overall effect: Z = 0.36 (P = 0.72)

Table 8 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of VAS Score, 5 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	0.5	0.32	34	0.05	0.01	39	41.8%	2.04 [1.47, 2.61]	
Thoen et al., (2020)	1	2	31	2	2	37	58.2%	-0.49 [-0.98, -0.01]	
Total (95% CI)			65			76	100.0%	0.57 [0.20, 0.93]	

Heterogeneity: Chi² = 43.87, df = 1 (P < 0.00001); I² = 98%
 Test for overall effect: Z = 2.99 (P = 0.003)

of migration, head penetration and wear on mediolateral axis five years after undergoing THA was obtained by Thoen, et al., (2020). Low mean average of 0.01±0.16 was obtained by Galea, et al., (2019). The pooled estimates for standard mean difference was -0.00 [95% CI -0.33-0.33]. Statistical difference between MxLPE and VEPE in terms of migration, head penetration and wear on mediolateral axis after 5 years of undergoing THA was not established (p = 1.000 >0.05; I² = 43%).

It could be seen in Table 6 that there was significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on longitudinal axis after 5 years of undergoing THA. The investigation disclosed, under the MxLPE group, a high mean average of 0.20±0.09. This was recorded by Thoen, et al., (2020). The low mean average of 0.08±0.24 was obtained by Galea, et al., (2019). In patients under the VEPE group, the high average mean of migration, head penetration and wear on

longitudinal axis 5 years post THA of 0.17±0.15 was reported by Thoen, et al., (2020) and the low mean average of 0.04±0.27 was obtained by Galea, et al., (2019). The pooled estimates for standard mean difference was 0.19 [95% CI -0.14-0.52]. Statistical difference between MxLPE and VEPE in terms of migration, head penetration and wear on longitudinal axis after 5 years of undergoing THA was not observed (p = 0.250 >0.05; I² = 0%).

Table 7 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on anteroposterior axis after 5 years of undergoing THA. In patients under the MxLPE group, the high mean average of 0.09±0.19 was obtained. This was recorded by Galea, et al., (2019). On the other hand, a low mean of 0.00±0.09 for migration, head penetration and wear on anteroposterior axis after 5 years of undergoing THA was noted by Thoen, et al., (2020). In patients involving the VEPE group, the high mean average of 0.1±0.24 was

Table 9 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Harris Hip Score, 2 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Salemyr et al., (2015)	87	17	26	90	12	25	24.6%	-3.00 [-11.05, 5.05]	
Sköldenberg et al., (2015)	41	13	21	48	12	21	27.8%	-7.00 [-14.57, 0.57]	
Thoen et al., (2020)	93	13	31	91	11	37	47.6%	2.00 [-3.79, 7.79]	
Total (95% CI)	78			83			100.0%	-1.73 [-5.73, 2.26]	

Heterogeneity: Chi² = 3.55, df = 2 (P = 0.17); I² = 44%
 Test for overall effect: Z = 0.85 (P = 0.39)

Table 10 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of Harris Hip Score, 5 Years Post Total Hip Arthroplasty

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	97	13.22	34	94	15.22	39	51.8%	0.21 [-0.25, 0.67]	
Thoen et al., (2020)	88	16	31	90	12	37	48.2%	-0.14 [-0.62, 0.34]	
Total (95% CI)	65			76			100.0%	0.04 [-0.29, 0.37]	

Heterogeneity: Chi² = 1.06, df = 1 (P = 0.30); I² = 6%
 Test for overall effect: Z = 0.23 (P = 0.82)

obtained by Galea, et al., (2019) while a low mean average (-0.02±0.13) was obtained by Thoen, et al., (2020). The pooled estimates for standard mean difference was 0.06 [95% CI -0.27-0.39]. There was no significant difference between MxLPE and VEPE when patients were grouped according to migration, head penetration and wear on anteroposterior axis after 5 years of undergoing THA (p = 0.720 >0.05; I² = 0%).

Table 8 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of VAS score after 5 years of undergoing THA. In patients under the MxLPE group, a higher VAS score (1.00±2.00) was obtained by Thoen, et al., (2020). On the other hand, Galea, et al., (2019) obtained a mean average VAS score of 0.50±0.32. With regard to patients enrolled under the VEPE group, the high VAS score mean of 2.00±2.00 was recorded by Thoen, et al., (2020) and this was followed by a mean VAS score of 0.05±0.01. This was noted by Galea, et al., (2019). The pooled estimates for standard mean difference was 0.57 [95% CI 0.20-0.93]. There was a significant difference between MxLPE and VEPE when patients were categorized according to mean VAS score 5 years after these patients had undergone hip arthroplasty (p = 0.003 <0.05; I² -98%) with VAS score of patient under the MxLPE noticeably lower than those who were under the VEPE group.

Table 9 presents the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of Harris Hip score after 2 years of undergoing THA. In the MxLPE group, the highest Harris Hip score mean average of 93.00±13.00 was obtained by Thoen and colleagues (2020) while the lowest mean Harris Hip score of 41.00±13.00 was recorded by Skoldenberg, et al., (2015). With patients enrolled under the VEPE group, the highest mean Harris Hip score of 91.00±11.00 was obtained by Thoen, et al., (2020). On the other hand, the lowest mean Harris Hip score (48.00±12.00) was reported by Skoldenberg, et al., (2015). The pooled estimates for standard mean difference was -1.73 [95% CI -5.73-2.26]. There was no significant difference between MxLPE and VEPE when patients were grouped according to their Harris Hip score 5 years after undergoing THA (p = 0.390 >0.05; I² = 44%)

Table 10 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of Harris Hip score after 5 years of undergoing THA. In the study, the high mean score of Harris Hip score was obtained by Galea, et al., (2019) where a mean average of 97.00±13.22 was obtained while a low mean Harris Hip score of 88.00±16.00 was recorded by Thoen, et al., (2020). In the VEPE group, the high mean Harris

Table 11 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of EuroQoL five-dimension three-level (EQ5D)

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	1	2.5	34	1	2.1	39	31.3%	0.00 [-0.46, 0.46]	
Salemyr et al., (2015)	0.87	0.22	26	0.92	0.14	25	21.8%	-0.27 [-0.82, 0.29]	
Sköldenberg et al., (2015)	0.4	0.3	21	0.5	0.3	21	17.8%	-0.33 [-0.94, 0.28]	
Thoen et al., (2020)	1	0.4	31	1	0.4	37	29.1%	0.00 [-0.48, 0.48]	
Total (95% CI)	112			122			100.0%	-0.12 [-0.37, 0.14]	

Heterogeneity: Chi² = 1.22, df = 3 (P = 0.75); I² = 0%
 Test for overall effect: Z = 0.88 (P = 0.38)

Table 12 Significant Difference between Moderately Cross-linked Polyethylene Liner versus Vitamin E Diffused Highly Cross-linked Polyethylene Liner in terms of University of California, Los Angeles (UCLA) Activity Score

Study or Subgroup	MxLPE			VEPE			Weight	Std. Mean Difference IV, Fixed, 95% CI	Std. Mean Difference IV, Fixed, 95% CI
	Mean	SD	Total	Mean	SD	Total			
Galea et al., (2019)	7	1.22	34	7	2.3	39	51.9%	0.00 [-0.46, 0.46]	
Thoen et al., (2020)	7	2.12	31	7	2	37	48.1%	0.00 [-0.48, 0.48]	
Total (95% CI)	65			76			100.0%	0.00 [-0.33, 0.33]	

Heterogeneity: Chi² = 0.00, df = 1 (P = 1.00); I² = 0%
 Test for overall effect: Z = 0.00 (P = 1.00)

Hip score of 94.00±15.22 was similarly recorded by Galea, et al., (2019) and the low mean score of 90.00±12.00 was obtained by Thoen, et al., (2020). The pooled estimates for standard mean difference was 0.04 [95% CI -0.29-0.37]. There was no significant difference between MxLPE and VEPE groups when patients were grouped according to their Harris Hip score taken 5 years after undergoing THA (p = 0.820 >0.05; I² = 6%).

Table 11 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of EuroQoL five-dimension three-level (EQ5D). In the study involving patients under the MxLPE, the highest mean averages of 1.00±2.50 and 1.00±0.400 were obtained by Galea, et al., (2019) and Thoen, et al., (2020) respectively. On the other hand, the lowest mean average of EQ5D (0.40±0.300 was recorded by Skoldenberg, et al., (2015). Among patients under the VEPE group, the highest mean averages of 1.00±2.10 and 1.00±0.40 were obtained by Galea, et al., (2019) and Thoen, et al., (2020) respectively while the lowest mean average of EQ5D (0.50±0.30) was obtained by Skoldenberg, et al., (2015). The pooled estimates for standard mean difference was -0.12 [95% CI -0.37-0.14]. Statistical significance between MxLPE and VEPE in terms of EQ5D was not observed (p = 0.380 >0.05; I² = 0%).

Table 12 shows the significant difference between moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene liner in terms of University of California, Los Angeles (UCLA) activity score . In the study, the highest mean average obtained in patients under the MxLPE group was 7.00±2.12 and this was observed by Thoen, et al., (2020). The lowest mean average of 7.00±1.22 was recorded by Galea, et al., (2019). In patients under the VEPE group, the high mean average of 7.00±2.30 was obtained by Galea, et al., (2019) and this was followed by a mean average of 7.00±2.00 recorded by Thoen, et al., (2020). The pooled estimates for standard mean difference was 0.00 [95% CI -0.48-0.40]. There was no statistical difference between the MxLPE and VEPE groups when patients were categorized according to UCLA activity score (p = 1.000 >0.05; I² = 0%).

DISCUSSION

Total hip arthroplasty (THA) is a procedure commonly performed to address various end-stage hip diseases such as rheumatoid arthritis, degenerative diseases such as developmental dysplasia, degenerative joint disease and even osteonecrosis.[14] In the modern era of Medicine, THA is found to last longer than ever before due to the fact that there has been improvement in bearing surfaces and materials available.[15] Despite these modern

approaches, failure caused by polyethylene wear, aseptic loosening, instability and mispositioning and even infection could affect the THA survival. In the course of addressing the anti-wear characteristics of the conventional polyethylene surface, various approaches have been made. To date, there are very limited studies done on which polyethylene liner is better.[16] Polyethylene wear is known to be associated with the manufacturing process and patient characteristics.

In the past two decades, modernization in the manufacturing of polyethylene, such as crosslinking and incorporation of vitamin E had led to a dramatic decrease of the needed revision on patients. [17-18] It is in this regard that this study was conducted in order to compare the effects of vitamin E diffused highly cross-linked polyethylene liner versus moderately cross-linked polyethylene liner in THA. In the investigation that was conducted, the researcher noted no statistical significance between moderately cross-linked polyethylene liner and vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on mediolateral, longitudinal and anteroposterior axes after 2 and 5 years of undergoing THA. The data suggests that vitamin E diffused highly cross-linked polyethylene liner is comparable with the conventional moderately cross-linked polyethylene liner.

The results were found to be in concordance with other studies that also investigated the outcome of vitamin E diffused highly cross-linked polyethylene liner (VEPE). In these studies, they noted that the addition of vitamin E in the manufacturing of polyethylene liner could show marked improvement in the clinical performance and mechanical properties of the polyethylene liner.[19-20] It is known that vitamin E acts as a scavenger that targets free radicals. Due to this, it has an effect on the reduction of bioactivity of polyethylene debris, formation of biofilms and adhesion of bacteria on surfaces.[21] In the meta-analysis done, the results of VEPE and MxLPE were almost similar as far as migration, head penetration and wear were concerned. These studies were similarly supported by investigations which also reported no significant difference between these two bearing surfaces.[22-23] In fact, one research has even mentioned that VEPE has shown encouraging early wear results in patients who had undergone THA.[24]

In one research, it was mentioned in passing that VEPE showed promising results with regard to stability.[25] This may be another reason as to why in the current meta-analytical assessment done, there was no significant difference between the two polyethylene liners. Moreover, patient reported outcomes and clinical outcomes measure also indicated no statistical significance between moderately cross-linked polyethylene liner and vitamin E diffused highly cross-linked polyethylene liner. This was also observed by some investigations where they also noted an almost similar data about these polyethylene liners, although these studies very highly recommended that a follow-up study be done to further establish their respective findings. [26-28]

CONCLUSION

Based on the findings drawn from the research study, the following conclusions are drawn from the study results:

The investigation disclosed no statistical significance between moderately cross-linked polyethylene liner and vitamin E diffused highly cross-linked polyethylene liner in terms of migration, head penetration and wear on mediolateral, longitudinal and anteroposterior axes after 2 and 5 years of undergoing THA. In all probability, the results indicate that vitamin E diffused highly cross-linked polyethylene liner is comparable with the conventional moderately cross-linked polyethylene liner. This may be considered since its effect on THA was found to be similar with that of the moderately cross-linked polyethylene liner. This was based on the fact that VEPE showed an almost similar stability as regards its wear rates and that the component showed similar stability with that of the moderately cross-linked polyethylene liner.

Moreover, the data pertaining to patient reported outcomes and clinical outcomes measure also indicated no statistical significance between moderately cross-linked polyethylene liner and vitamin E diffused highly cross-linked polyethylene liner. In this regard, the results that may be obtained, such as functional and activity scores, when patients undergo VEPE approach would be similar to that of those who were provided with moderately cross-linked polyethylene liner.

RECOMMENDATIONS

Based on the conclusions drawn in the current research study, the following recommendations are forwarded:

Patients who will undergo THA may be provided with either moderately cross-linked polyethylene liner or vitamin E diffused highly cross-linked polyethylene provided that there are no contraindications to the implant and procedure. This recommendation is based on the fact that VEPE yielded no statistical difference between moderately cross-linked polyethylene liner.

The utilization of vitamin E diffused highly cross-linked polyethylene liner may be promoted to patients since its safety and efficacy is comparable

to that of the conventional moderately cross-linked polyethylene liner yielding an almost similar functional and activity scores.

Since there are no actual studies about moderately cross-linked polyethylene liner versus vitamin E diffused highly cross-linked polyethylene that involve Filipino patients, a randomized clinical trial is suggested as a potential topic that should be covered by future researchers.

An investigation solely centering on complications that may be experienced by patients under moderately cross-linked polyethylene liner or vitamin E diffused highly cross-linked polyethylene 10 years after undergoing surgery is very highly suggested as a future topic to be considered by other medical residents of this medical institution.

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