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Original article

Does cross-linked polyethylene decrease the revision rate of total hip arthroplasty compared with conventional polyethylene? A meta-analysis

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ABSTRACT

Background: Although cross-linked polyethylene is resistant to wear in comparison to conventional polyethylene, it remains unknown whether it can decrease the wear-related revision rate of total hip arthroplasty.
Objectives: To determine whether cross-linked polyethylene decreases the wear-related revision rate of total hip arthroplasty compared with conventional polyethylene.
Data sources: Electronic databases, including PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials, were queried from inception to July 6, 2013.
Study selection: Randomized controlled trials (RCTs) comparing cross-linked polyethylene with conventional polyethylene were included. In addition, the standard 28-mm femoral head was used, and follow-up was performed for a minimum of 5 years. The primary outcome assessed was wear-related revision. The secondary outcome measures evaluated were the incidence of osteolysis, the linear wear rate, and the linear head penetration.
Data synthesis: The Cochrane Collaboration's tool for assessing the risk of bias was used for quality assessment. Data from eligible studies were pooled using a random effects model.
Results: Eight studies involving 735 patients were included in this study. Meta-analysis showed there was no significant difference between cross-linked and conventional polyethylene group in terms of osteolysis or wear-related revision. The pooled mean differences were significantly less for the linear wear rate and linear head penetration for cross-linked polyethylene than for conventional polyethylene.
Limitations: The studies differed with respect to the cross-linked liner brands, manufacturing processes, and radiological evaluation methods. Moreover, the follow-up periods of the RCTs were not long enough.
Conclusions: The current limited evidence suggests that cross-linked polyethylene significantly reduced the radiological wear compared with conventional polyethylene at midterm follow-up periods. However, there is no evidence that cross-linked polyethylene had an advantage over conventional polyethylene in terms of reducing osteolysis or wear-related revision. Nevertheless, future long-term RCTs on this topic are needed.
Key findings: Cross-linked polyethylene significantly reduced radiological wear but not osteolysis or wear-related revision in comparison to conventional polyethylene at midterm follow-up periods.
Level of evidence: Level I, systematic review of level I studies.

1. Introduction

Although total hip arthroplasty (THA) has provided satisfactory results for over four decades, the optimal bearing surface remains controversial. Hard bearing surfaces such as ceramic-on-ceramic (CoC) and metal-on-metal (MoM) have outstanding wear performance [1,2], but they have their own inherent limitations and may not be suitable for all patients. CoC bearings have been documented to squeak or fracture catastrophically [3,4]. MoM bearings have been associated with increased metal ion levels in serum [5]. Metal-on-polyethylene bearings have been used as the main material for contact surfaces in THA; however, the survivorship has been limited by aseptic loosening and osteolysis secondary to wear and particulate polyethylene debris [6,7].

To reduce the volume of wear debris generated at the bearing surface and thereby improve the longevity of the prosthesis, several

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changes in the manufacturing process for conventional polyethylene have been instituted over the last two decades. The most relevant modification has been the use of irradiation with an electron beam or with gamma radiation to increase the number of cross-links between the polymer chains [8–10]. The resulting materials are known as cross-linked polyethylenes.

In vitro analysis has shown that cross-linked polyethylene has a greatly increased resistance to wear in comparison to conventional polyethylene [10,11]. Similarly, some randomized controlled trials (RCTs) have shown that the use of cross-linked polyethylene leads to less wear than the use of conventional polyethylene [12–15]. As most of these studies had short-term follow-ups, it remains unknown whether these improvements result in less aseptic loosening and improved implant longevity in the long-term. Several systematic reviews have compared cross-linked and conventional polyethylenes [16–18]. The weakness of these studies is the inclusion of short-term trials, thereby compromising the ability to gain information on wear-related revision outcomes. Recently, several RCTs with midterm (five-to-ten-year) and long-term (more than ten-year) follow-ups have been published [19–22].

In light of these issues, the present meta-analysis of data from RCTs aimed to provide an evidence-based appraisal of the effects of cross-linked polyethylene compared with conventional polyethylene in patients who underwent THA. We postulated that cross-linked polyethylene demonstrates a lower incidence of wear-related revision at midterm to long-term follow-up compared with conventional polyethylene.

2. Methods

2.1. Data sources and searches

Electronic databases, including PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials, were queried for search terms in the following format: (arthroplasty, replacement, hip [mh] or total hip arthroplasty or total hip replacement or THA OR THR) and (cross-linked or cross-linked or cross-linking). Reference lists of relevant articles were manually searched for additional trials. The search was not restricted by language. The latest date for this search was July 6, 2013.

2.2. Inclusion criteria

Studies eligible for inclusion met the following criteria:

- RCT;
- patients underwent THA;
- both cross-linked and conventional polyethylene liners were included;
- only the standard 28-mm femoral head was used;
- reported wear-related revision outcome;
- follow-up was performed for a minimum of 5 years.

All studies that did not meet these criteria were excluded.

2.3. Data extraction and outcome measures

Two reviewers independently extracted data using a standardized extraction form. Disagreements were resolved by discussion until consensus was reached. In the case that the two reviewers could not reach a consensus, a third reviewer was asked for a final opinion, resulting in a group consensus. The primary outcome assessed was wear-related revision. Secondary outcome measures were the incidence of osteolysis, the linear wear rate, and the linear head penetration. These outcome measures were chosen because they were included in most studies.

2.4. Quality assessment

The Cochrane Collaboration's tool for assessing the risk of bias was used for quality assessment [23]. This tool focuses on seven criteria:

- sequence generation;
- allocation concealment;
- blinding of participants and personnel;
- blinding of outcome assessment;
- incomplete outcome data;
- selective outcome reporting;
- other sources of bias.

Each RCT was classified as "low risk" "high risk" or "unclear risk" for each criterion.

2.5. Statistical analysis

For dichotomous outcomes, the risk difference (RD) and 95% confidence interval (CI) were calculated as the summary statistics. For continuous outcomes, data means and standard deviations (SDs) were used to calculate a weighted mean difference (WMD) and 95% CI in the meta-analysis. Heterogeneity between studies was quantified using the I^2 statistic. An I^2 value of 0% represents no heterogeneity, and values of 25%, 50%, and 75% or more represent low, moderate, and high heterogeneity, respectively [24]. Data from eligible studies were pooled using a random effects model because of the anticipated heterogeneity among study populations, follow-up durations, implant brands, manufacturing processes, and radiological evaluation methods. A sensitivity analysis was performed to explore possible explanations for heterogeneity. A P-value < 0.05 was judged as statistically significant, except where otherwise specified. All statistical tests were performed with Review Manager (Version 5.1, The Cochrane Collaboration).

3. Results

3.1. Literature search

Of the 961 potentially relevant studies identified through the literature search (Fig. 1), 38 studies were retrieved for

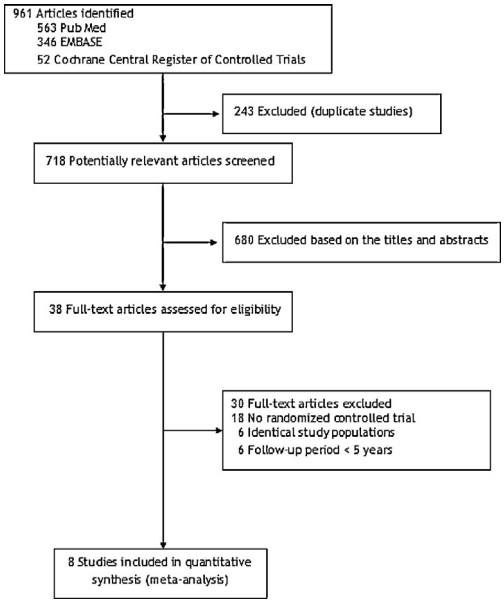

Fig. 1. Flow diagram of the study with a summary of the search process. Seven studies were included in the final analysis.