Research & Reviews: Journal of Medical and Health Sciences

e-ISSN: 2319-9865
p-ISSN: 2322-0104
www.rroij.com

A Literature Review of the Clinical Evidence Situation of Bone Cements

Pilz V* and Hanstein T

Department of Health Economics, Heraeus Medical GmbH, Wehrheim, Germany

***For Correspondence:** Pilz V, Department of Health Economics, Heraeus Medical GmbH, Wehrheim, Germany, Tel: +49 (0) 171 3 07 15 51; E-mail: veronika.pilz@heraeus.com

Received date: 19/03/2018; **Accepted date:** 24/03/2018; **Published date:** 31/03/2018

Review Article

ABSTRACT

Bone cements based on Polymethyl methacrylate (PMMA) are essential products in orthopaedic surgery being popularized in the early 1960s, already. On the basis of its use over several decades, Arthroplasty registries analysed long-term results demonstrating differences in terms of revision risks for different bone cement brands. In this study, we aimed to investigate the evidence situation in regards to different bone cements of the most used brands in joint replacement. We performed a literature review by two reviewers independently to identify primary and secondary articles that described and evaluated the use of bone cement in surgical procedures, including orthopaedic, trauma and neurosurgery. The level of evidence was then graded using the Journal of Bone and Joint Surgery (JBJS) hierarchy. Out of 1.424 articles identified, 178 articles met the inclusion criteria. The bone cement Palacos manufactured by Heraeus Medical sums up to the best studied bone cement incorporating 136 clinical studies which are furthermore dating back the longest time period including 8.990 patients. The average quality of included studies was best for bone cements manufactured by Tecres and Smith & Nephew.

Keywords: Orthopaedics, Arthroplasty, Bone cement, Literature review, Evidence

INTRODUCTION

Bone cements based on Polymethyl methacrylate (PMMA) are essential products in orthopaedic surgery. Otto Rohm and the company Kulzer were early pioneers (1943) who worked extensively on the physical properties and use of bone cement [1]. Originally developed for dental applications, bone cement has been used successfully in arthroplasty surgery for more than 50 years now. In the early 1960s, Charnley [2] popularized PMMA for the fixation of a hip prosthesis. Although being in use for several decades, some cement have remained unchanged and maintained a reliable formulation extending their long-term outcome results. On the other hand, others were further developed [3] or even disappeared after disastrous outcome data, e.g. the "Boneloc-Disaster" detected by the Scandinavian Arthroplasty registries [4,5].

The various bone cement brands are characterized by differing properties as handling, doughing or working times [6]. The co-polymer compositions, the amount of admixed antibiotics and the antibiotic release characteristics vary widely with an impact on clinical application [7]. Although, only making up a small part of medical devices used in a joint replacement procedure, the type of bone cement seems to have an significant influence on the outcome: Arthroplasty registries demonstrated that there are differences in terms of revision risks for different bone cement brands [8,9].

Hence, in this study, we have investigated the evidence situation in regards to different bone cements of the most used brands in joint replacement [10,11]. Given the long history of bone cement, it is hypothesized that a large amount of therapeutic studies should have been accumulated. Therefore, we summarized the total number of therapeutic studies and further evaluated the associated evidence level of the studies.

e-ISSN: 2319-9865
p-ISSN: 2322-0104

MATERIALS AND METHODS

Search Strategy and Selection Criteria

We performed a literature review to identify articles that described and evaluated the use of bone cement in orthopaedic procedures. We searched into PUBMED database for articles published until 15 January 2018. The research keywords were: [(Refobacin) & (bone cement)), (Optipac), (CMW), (Smartset), (Smartmix), ((Cobalt) AND (bone cement)), ((Cobalt) & (Biomet)), ((Cobalt) & (DJO)), (Palacos), (Palamed), ((Copal) & (bone cement)), (Versabond), ((Rally) & (bone cement)), ((Rally) & (Smith & Nephew)), ((Simplex) & (bone cement)), ((Simplex) & (Stryker)), (Cemex), ((Hi Fatigue) & (bone cement)), ((Hi Fatigue) & (Zimmer)].

Publications were retrieved based on whether the title and abstract or, if required, the full manuscript met the inclusion criteria for this review. We selected primary and secondary articles that described and evaluated the use of bone cement in surgical procedures, including orthopaedic, trauma and neurosurgery. All articles were screened if they provided a sufficient description and if the bone cement product name or manufacturer has been mentioned. Finally, due to resource constraints and ease of access, articles that were published in any language other than English or German, or articles that were unpublished were excluded from the analysis.

Data Extraction and Evaluation

Table 1. Levels of evidence of therapeutic studies according to JBJS (Wright [12]).

Evidence Level	Description
Level I	Systematic Review of Level I RCTs and study results were homogenous
	High quality RCT with statistically significant difference or narrow confidence intervals
Level II	Prospective cohort study
	Poor quality RCT
	Systematic review of Level II studies or Level I studies with non-homogenous results
Level III	Case control study
	Retrospective cohort study
	Systematic review of Level III studies
Level IV	Case series (no or historical control group)
Level V	Expert Opinion

Two reviewers independently screened and selected the articles using a standardized form for extracting relevant information. All data were extracted independently by both reviewers and then checked for disagreements. All disagreements between the two reviewers were discussed.

We chose to include all relevant articles, regardless of their quality assessment, in an exploratory approach. The level of evidence was then graded using the Journal of Bone and Joint Surgery (JBJS) hierarchy **(Table 1)**. Whilst randomised controlled trials (RCT) or systematic reviews are considered the highest level of evidence similar like in other evidence hierarchies, the quality and outcome of the studies are also included in the evidence rating by JBJS [12,13].

RESULTS

The literature search identified 1.424 articles. After the selection process, the reviewers agreed that 178 articles met the inclusion criteria for the review. The flowchart in **Figure 1** outlines the process for selecting included articles. Most of the articles described experimental studies with experimental animal or in vitro study designs. These designs were excluded according to the JBJS criteria as only therapeutic studies are classified herein.

e-ISSN: 2319-9865
p-ISSN: 2322-0104

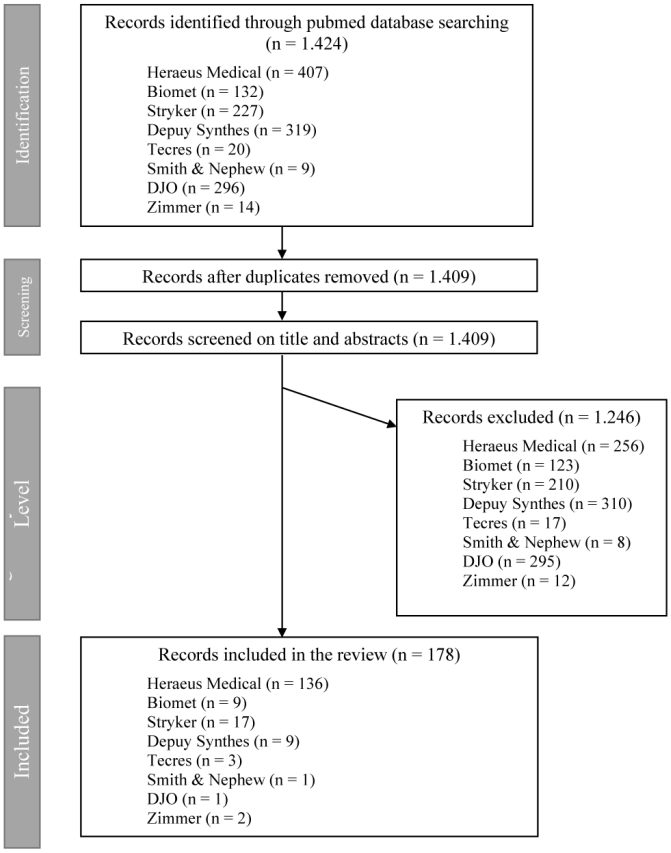

Figure 1. Flow diagram: Process of review selection.

Furthermore, all studies describing dental procedures or the generic use of a brand name for the description of any unnamed bone cement were excluded.

Sample sizes ranged from only case reports to register studies including over 20.000 patients. For evaluation of the number of included participants in the studies, we decided to exclude patients from register studies in means of comparability.

In our literature search, we identified 136 publications studying bone cement manufactured by Heraeus Medical; 17 studies with bone cement manufactured by Stryker; 9 studies by DePuy Synthes; 9 studies by Biomet, 3 studies by Tecres, 2 by Zimmer and only 1 study meeting our inclusion criteria by Smith & Nephew and DJO. Study counts by product are shown in **Table 2** whereas Palacos manufactured by Heraeus Medical sums up to the best studied bone cement incorporating 136 clinical studies. The cumulative numbers of studies over time can be seen in **Figure 2**. In this figure, it can also be depicted that studies investigating bone cement by Heraeus Medical date back the longest time period.

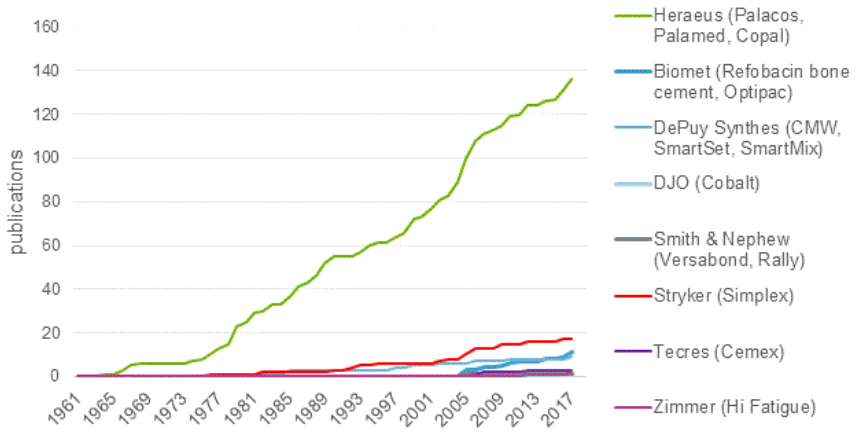

Figure 2. Cumulative number of publications over time by manufacturer of bone cements.

e-ISSN: 2319-9865
p-ISSN: 2322-0104

In our analysis, we also investigated the number of patients included in the studies. 8.990 patients were included in studies analysing bone cement of Heraeus Medical, Palacos bone cement in specific. Successively, Stryker has included 832 patients and DePuy Synthes 232. The other manufacturers are following with patient counts below 200.

Table 2. Total number of publications by manufacturer and products.

Manufacturer/Product	Studies
Heraeus Medical	
Palacos	136
Palamed	3
Copal	1
Stryker	
Simplex	17
DePuy Synthes	
CMW	9
Smartset	0
Smartmix	0
Biomet	
Refobacin	8
Optipac	1
Tecres	
Cemex	3
Zimmer	
Hi Fatigue	2
Smith & Nephew	
Versabond	1
DJO	
Cobalt	1

All included studies were ranked according to the JBJS evidence criteria. The average quality of included studies by manufacturer of the bone cements are shown in **Figure 3**. It can be seen that studies regarding bone cements manufactured by Tecres and Smith & Nephew have the best study quality. On the other hand, only few studies were included in this calculation which is reducing the validity of the results.

e-ISSN: 2319-9865
p-ISSN: 2322-0104

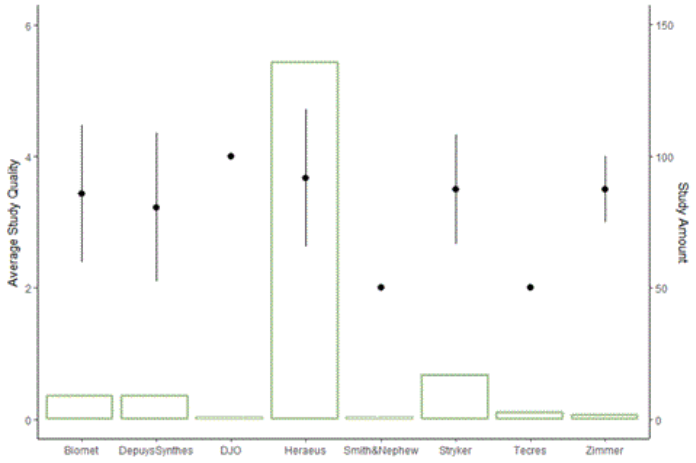

Figure 3. Cumulative Study quality of included studies per manufacturer. Average study quality indicated as dot and standard deviation indicated as whiskers. Total numbers of study included per manufacturer indicated as bar plots.

DISCUSSION AND CONCLUSION

In our analysis, we investigated the evidence situation in regards to different bone cements of the largest manufacturers on the market. The highest number of therapeutic studies was found for bone cement manufactured by Heraeus Medical, whereas best study quality on average was found for bone cements manufactured by Tecres and Smith & Nephew.

Given the long history of Palacos bone cement by Heraeus Medical it is not surprising that also the published study history is the largest, dating back the longest time period. There is no other literature review published regarding this topic and also publications where bone cements are compared directly are rare. Bone cements manufactured by Tecres and Smith & Nephew were found to have on average the best study quality. However, it has to be mentioned that only few studies were selected regarding these cements whereas the informative value and the significance of the results are very low.

This literature review gives a comprehensive overview over the evidence situation regarding bone cement. We included all articles until January 2018 and did not set a cut-off in the analysing period. This means that not only elder publications but also most recent ones were analysed in this review. Nevertheless, a key limitation in this literature review is the heterogeneity of the reported outcome in the included studies and that the outcome was assessed herein. However, we are able to make a statement regarding the study amount and the study quality.

REFERENCES

1. Arora M, et al. Polymethylmethacrylate bone cements and additives: A review of the literature. World J Orthop. 2013;4:67-74.
2. Charnley J. The bonding of prostheses to bone by cement. J Bone Joint Surg Br. 1964;46518-46529.
3. Kьhn K. PMMA Cements: Are we aware what we are using? The role of PMMA cement, it's properties, it's choice, it's application, it's clinical evidence, it's function in infected revisions and S outlooks for easier cement usage. Springer. 2014.
4. Nilsen AR, et al. Total hip arthroplasty with Boneloc: Loosening in 102/157 cases after 0.5-3 years. Acta Orthop Scand. 1996;67:57-59.
5. Liebensteiner M, et al. Detection of inferior products in arthroplasty and implementation of findings: A retrospective analysis of the Boneloc incident. Z Orthop Unfall. 2009;147:683-688.
6. He S, et al. Effect of choice of surgical gloves on dough time measurements of acrylic bone cement. Biomaterials. 2003;24:235-237.
7. Frommelt L, et al. Antibiotic-loaded cement. In: The Well-Cemented Total Hip Arthroplasty. Berlin/Heidelberg: Springer-Verlag. 2005;86-92.
8. Herberts P, et al. Long-term registration has improved the quality of hip replacement: A review of the Swedish THR Register comparing 160,000 cases. Acta Orthop Scand. 2000;71:111-121.

9. Trela L, et al. The association between cement type and the subsequent risk of revision surgery in primary total hip replacement. Acta Orthop. 2018;89:40-46.
10. http://www.njrcentre.org.uk/njrcentre/Portals/0/Documents/England/Reports/11th_annual_report/NJR%2011th%20AR%20Prostheses%20used%20in%20hip,%20knee,%20ankle,%20elbow%20and%20shoulder%20replacements%202013.pdf
11. https://aoanjrr.sahmri.com/documents/10180/42612/Annual%20Report%202007?version=1.1&t=1349406300550
12. Wright JG, et al. Introducing levels of evidence to the journal. J Bone Joint Surg Am. 2003;85:1-3.
13. Marx RG, et al. Updating the assignment of levels of evidence. J Bone Joint Surg Am. 2015;97:1-2.