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REVIEW

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Systematic review of the outcome of cemented versus uncemented total hip arthroplasty following pelvic irradiation

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Abstract

Purpose The objective of this study is to evaluate the outcomes of total hip arthroplasty (THA) in patients with radiation-related changes to the bone, and specifically whether there is a difference in outcomes between cemented and uncemented acetabular components.

Methods A database search was performed to identify available studies reporting adults undergoing THA who have previously had pelvic irradiation. Data were extracted and analysed with respect to the use of cemented versus uncemented acetabular components. Statistical analysis was performed using the Chi-square test for independence.

Results The all-cause revision rate was 24% in the cemented THA group (27/111), compared with 15% of uncemented THAs (22/143) ($p=0.073$). Revision for acetabular aseptic loosening occurred in 16% of cases (18/111) in the cemented group and 10% (15/143) in the uncemented group ($p=0.178$). Acetabular aseptic loosening was reported in 24% of cemented THAs (27/111) and 14% of uncemented THAs (20/143), which was statistically significant ($p=0.035$). Not all of these went on to have revision THA. The Incidence of prosthetic joint infection was similar in both groups.

Conclusion Overall outcomes appear to be better for uncemented THAs in post-radiotherapy patients, with a significantly lower rate of aseptic loosening and an appreciable (but not statistically significant) reduction in revision rate. The best outcomes seem to be associated with the use of acetabular reinforcement across both cemented and uncemented groups, but further work is needed to evaluate this.

Keywords Total hip arthroplasty · Total hip replacement · THA · THR · Radiation · Irradiation · Radiotherapy · Cemented · Uncemented

Introduction

Radiotherapy has long been used as a treatment for neoplastic diseases and often has a place in the management of various genitourinary, gastrointestinal, and haematological malignancies, as well as metastatic bone disease [1, 2]. When used in the context of pelvic malignancies, the side effects include damaging effects on local structures including the bones of the hip joint.

Radiation injury to bones occurs in a dose-dependent manner, with evidence of injury apparent after total doses exceeding 3000 cGy (centiGray), with higher doses associated with

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more pronounced radiological and histological changes [3, 4]. Radiation exposure impairs osteoblast function and causes damage to the vascular supply, leading to disorganized bony architecture characterized by areas of increased and decreased density, coarse trabeculation, and sclerosis [5].

Radiation to the pelvis can lead to a spectrum of injury to the hip joint, including pronounced degenerative change, radiation osteitis, pathological fracture and avascular necrosis [6–9]. These changes can result in significant functional impairment and pain, and therefore arthroplasty surgery is often performed in an attempt to improve the situation.

Several studies have reported total hip arthroplasty (THA) for patients who have previously had pelvic irradiation, considered in more detail later [10–17], with all accepting the common complication of aseptic loosening of the acetabular component. This complication is more pronounced in irradiated hips as a result of the damaged acetabular bone.

THA can be performed with or without the use of cement, each relying on a different mechanism for fixation. Cemented implantation relies on a well-fitted cement mantle around the component, and adequate interdigitation of the cement into the bone trabeculae, which is arguably achieved less effectively when cementing onto irradiated sclerotic bone [12]. Uncemented implantation relies on osseous integration of a porous component into trabecular bone, allowing new bone to form and remodel into the surface of the component. This process relies on healthy bone with a good blood supply, so in theory would also be compromised in the case of irradiated bone [13, 18].

As a result of the problems seen with both cemented and uncemented implants, it remains unknown which method achieves the best outcomes in the context of hips with radiation injury.

Objectives

The objective of this study is to evaluate the outcomes of total hip arthroplasty in patients with radiation-related changes to the bone, and specifically whether there is a difference between cemented and uncemented acetabular components. The primary outcome is failure of the prosthesis, as defined by requiring surgical revision as determined by the treating clinician. Secondary outcomes to be considered are aseptic loosening, prosthetic joint infection (likely overlap with primary outcome), patient-reported outcome measures, and any other complications.

Methods

This study was registered as a systematic review on the PROSPERO database (CRD42018089277).

Eligibility criteria

We included all available studies reporting adults undergoing total hip arthroplasty who have previously had pelvic irradiation. Data had to be available about the type of implants used, and a minimum of 2 years of follow-up was required in order to serve as a reasonable indication of complications, and complications including failure requiring revision had to be reported. No restrictions were applied to dates on searching, and all study types were considered, except for single case reports or small case series (less than five cases).

Search strategy

The following database searches were undertaken: Healthcare Databases Advanced Search (HDAS) for all available databases—AMED, BNI, CINAHL, EMBASE, HBE, HMIC, MEDLINE, PsycINFO, PubMed; Google Scholar; and Cochrane Library. Additionally, references from relevant articles were manually searched for any additional sources.

Data extraction (see PRISMA flow diagram—Fig. 1)

Search results were screened based on title and abstract. Abstracts of all potentially relevant studies were analysed by two reviewers independently, and full texts were acquired. Data were extracted with a pre-designed data collection table, in order to collate information relating to the study population, type of surgery performed, and any available outcome measures (see Table 1).

Statistical analysis

The data were treated as nonparametric, and outcome measures were analysed using the Chi-square test for independence (Microsoft Excel 2010).

Results

Search results (see PRISMA flow diagram—Fig. 1)

Database searching revealed 688 results across 5 databases. After screening of titles and abstracts, 15 articles were identified as potentially relevant and the full texts viewed. Seven of these were removed—1 was not relevant, 3 were series with less than 5 cases, and 3 were studies whereby the department had since published a newer superseding study.

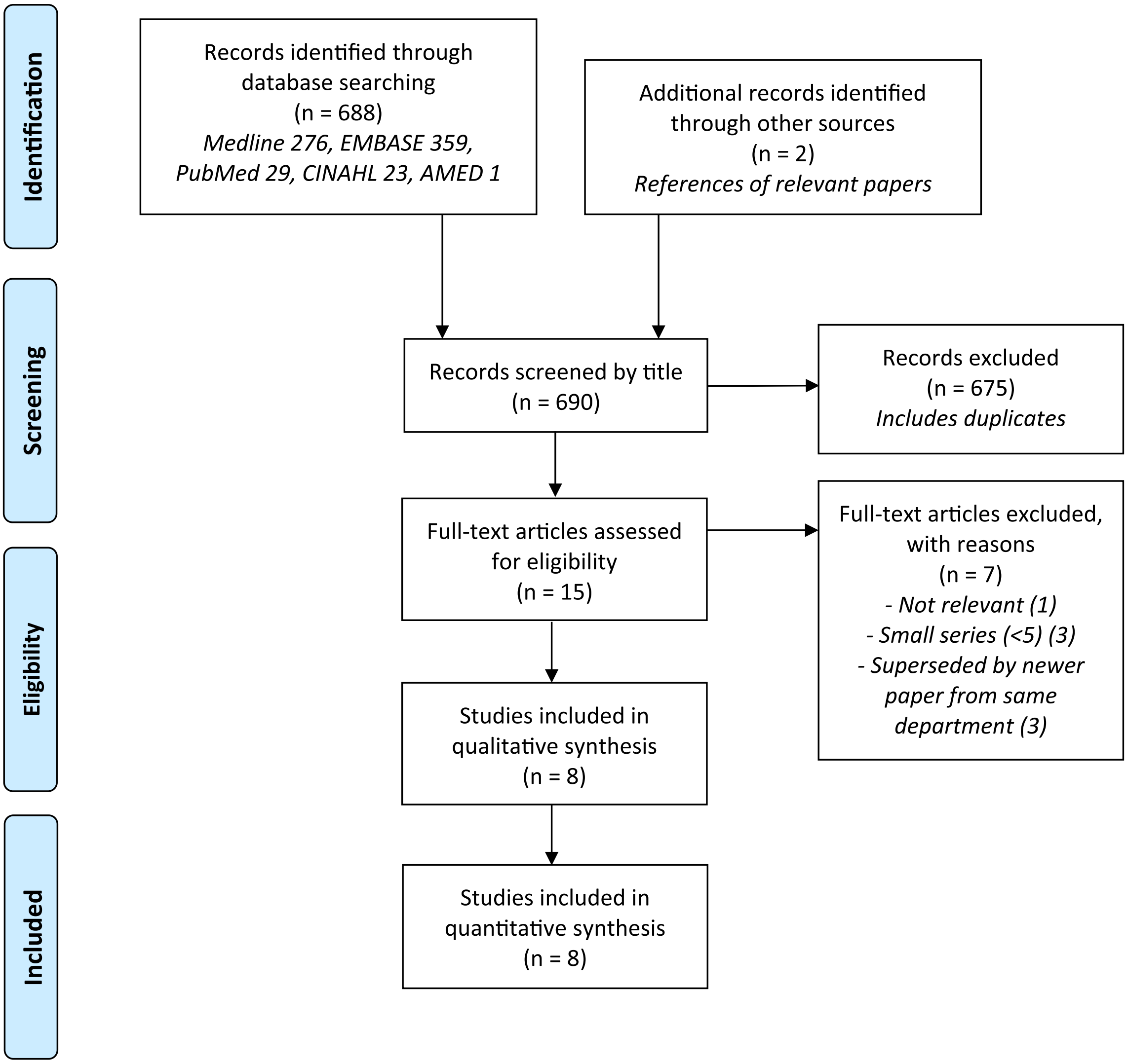

Fig. 1 PRISMA flow diagram [19]. For more information, visit www.prisma-statement.org

The remaining 8 articles were analysed and included in the results (Table 1).

Cohort characteristics

In total, we included 111 cemented THAs from 3 studies [10–12] and 143 uncemented THAs from 6 studies [11, 13–17], with one study providing cases for both the uncemented and cemented cohorts [11].

The mean ages of the 2 groups were similar at 65 and 66, respectively, and both groups included patients that had undergone radiotherapy for a variety of malignancies.

The mean time between radiation and THA was 67 months for the cemented group and 73 months for the uncemented group.

The mean follow-up time was 56 months for the cemented group and 61 months for the uncemented group.

The mean radiation dose per patient was 5238 cGy for the cemented group and 9223 cGy for the uncemented group; however, this result is skewed by the fact that one of the studies in the uncemented group used a much higher average radiation dose of 43000 cGy [16] due to a patient cohort with more disseminated disease or bone marrow cancers. With the removal of this study from this analysis, the mean radiation dose per patient in the uncemented group is 6129 cGy. However, this study will be left in for the remainder of the analysis as it may provide meaningful data.

Table 1 Summary of studies

First author	Year	No. of hips	Country	Age—mean (range)	Radiation dose (cGy) mean (range)	Reason for radiation	Time between radiation and THA (months) mean (range)	Type of acetabular reinforcement	Acetabular fixation
Cemented									
Massin Group 1 (1970–1982)	1995	42	France	60 (33–79)	5500 (range unknown)	Both groups: 40 uterine cancer 8 other pelvic cancers 9 metastases	73 (6–276)	None	Cemented
Massin Group 2 (1983–1990)	1995	16	France	63 (45–76)	5500 (range unknown)	As above	73 (6–276)	Ring—Muller (17), Burch (1), Eichler (4)	Cemented
Cho Group 2	2005	4	South Korea	64 (57–70)	4367 (4000–4600)	Cervical cancer (all)	114 (103–127)	Roof Ring	Cemented (Muller ring)
Felden	2015	49	France	69 (19–85)	5000 (3000–7200)	Variety of malignancies. Mostly prostate cancer, uterine cancer or metastases.	57 (3–372)	Kerboull reinforcement cross	Cemented
Total Cemented		111		65	5238	Variety of malignancies	67		Cemented
Uncemented									
Jacobs	1995	9	USA	67 (56–88)	4783 (2395–6202)	3 cervical cancer 3 endometrial cancer 1 lymphoma 1 prostate cancer	77 (25–228)	None	Uncemented (Harris-Galante I or II)
Cho Group 1	2005	14	South Korea	55 (37–67)	5550 (4050–6500)	Cervical cancer (all)	55 (7–130)	None	Uncemented (Harris-Galante II or Trilogy)
Kim	2007	58	USA	74 (56–89)	7065 (6440–7900)	Prostate cancer (all)	67 (1–292)	None	Uncemented (PSL or Universal)
Joglekar	2012	22	USA	71 (61–80)	6300 (4500–7380)	Variety of malignancies	90 (2–800)	Trabecular metal	Uncemented (Tantalum—Zimmer). Polyethylene liner cemented into shell.
De Paolis	2015	12	Italy	47 (25–77)	43000 (800–67000)	Variety of malignancies.	88 (13–364)	Trabecular metal	Uncemented (Tantalum—Zimmer)
Kang	2018	28 16 1990–2000 12 2001–2010	South Korea	60 (47–77)	4777 (4000–6100)	Cervical cancer (all)	Unknown	None	Uncemented (Harris-Galante II or Trilogy)
Total Uncemented		143		66	9223 (6129—De Paolis removed)	Variety of malignancies	73		Uncemented

Table 1 (continued)

First author	Year	Follow-up (months) mean (range)	Number of acetabular aseptic loosening	Number of prosthetic joint infection	Number revised—acetabular aseptic loosening	Number revised—total	Other complications	PROMs	Note
Cemented									
Massin Group 1 (1970–1982)	1995	69 (6–240)	22 (52%)	0	16 (38%) 6 Girdlestone 10 acetabular component (9 reinforcement rings)	20 (48%) +4 femoral	1 sarcoma, 1 sciatic palsy, 2 phlebitis, 1 haematoma, 5 dislocations	Merle d'Aubigne and Postel scale (1954) No results reported	Total 49 cases, but 7 excluded due to insufficient follow-up. All patients presumed radiation-related pathology as rapid deterioration in joint after radiation. 14 (20 pre-excl) metal-on-metal. 28 (29 pre-excl) metal-on-polyethylene. Higher acetabular failure rate with metal-on-metal (86% vs 39%).
Massin Group 2 (1983–1990)	1995	40 (6–132)	2 (12%)	2 (12%)	0 (both had acceptable function + died 2 years post-op)	2 (13%) Girdlestone for infection	1 femoral fracture, 1 acetabular fracture, 1 haematoma, 2 dislocations	Merle d'Aubigne and Postel scale (1954) Reports for 11 hips: 2—fair clinical result 4—good 5—excellent	Total 22 cases, but 6 excluded due to insufficient follow-up. All patients presumed radiation-related pathology as rapid deterioration in joint after radiation. All metal-on-polyethylene.
Cho Group 2	2005	33 (20–41)	2 (50%)	0	1 (25%) Ganz	1 (25%)	1 patient died (sarcoma)	Modified Harris hip score 67% of patients had HHS < 80, not subdivided by cemented/uncemented	All cases for radiation necrosis of femoral head and acetabulum. All metal-on-polyethylene. Showed association between latent period and risk of failure.
Felden	2015	51 (15–242)	1 (2%)	3 (6%)	1 (2%) 1 one-stage revision for aseptic loosening PMA 14	4 (8%) +3 revisions for infection (2 one-stage, 1 two-stage)	19 patients died. 71% survival at 2 years, 52% survival at 5 years, 41% survival at 10 years.	Postel Merle d'Aubigne score (PMA). Pre-operative median score of 9 Final follow-up—median PMA of 15 5 hip mobility 6 pain 5 walking	20 cases (41%) for radiation osteitis. 17 cases (35%) for avascular necrosis of the femoral head. 12 cases (24%) for pathological fracture of the femur/acetabulum. All metal-on-polyethylene.
Total Cemented		56	27 (24%)	5 (5%)	18 (16%)	27 (24%)			

Table 1 (continued)

First author	Year	Follow-up (months) mean (range)	Number of acetabular aseptic loosening	Number of prosthetic joint infection	Number revised—acetabular aseptic loosening	Number revised—total	Other complications	PROMs	Note
Uncemented									
Jacobs	1995	37 (17–78)	4 (44%)	0	2 (22%) 1 uncemented—failed—Girdlestone 1 cemented 1 refused 1 died of other cause	2 (22%)	2 patients died during study period (lymphoma/pneumonia)	Modified Harris hip score Average score of 82 for stable implants (41 pre-op) Average of 60 for failed implants (47 pre-op)	Total 12 cases, but 3 excluded due to insufficient follow-up (death). 5 cases for avascular necrosis. 4 cases for osteoarthritis. All metal-on-polyethylene.
Cho Group 1	2005	75 (37–139)	7 (50%)	0	6 (43%) 4 Muller 2 Ganz	6 (43%)	1 patient died (renal failure)	Modified Harris hip score 67% of patients had HHS < 80, not subdivided by cemented/uncemented	All cases for radiation necrosis of femoral head and acetabulum. All metal-on-polyethylene. Showed association between latent period and risk of failure.
Kim	2007	58 (24–90)	0	1 (2%)	0	3 (5%) 1 Girdlestone (infection) + 2 femoral 1 revision of femoral component 1 revision for periprosthetic fracture of femur	3 patients died 1 dislocation	Harris hip score/SF-36 Mean HHS improved from 47 pre-op to 90 post-op SF-36 improved: Physical—45.1 to 73.4 Mental—65.3 to 83.7	Total 66 cases, but 8 excluded due to insufficient follow-up (4 died within 2 years, 4 lost to follow-up). 35 cases (53%) for osteoarthritis. 31 cases (47%) for radiation osteonecrosis. 30 ceramic-on-ceramic. 36 metal-on-polyethylene.
Joglekar	2012	78 (57–116)	0	0	0	0	1 intra-operative femoral fracture	Harris hip score Mean pre-op score of 36 Mean 5-year score of 80	Total 34 cases, but 12 excluded due to < 5 years follow-up (10), cognitive decline precluding evaluation (1) and refusal to participate (1). All cases for radiation osteitis or osteonecrosis. All metal-on-polyethylene.

Table 1 (continued)

First author	Year	Follow-up (months) mean (range)	Number of acetabular aseptic loosening	Number of prosthetic joint infection	Number revised—acetabular aseptic loosening	Number revised—total	Other complications	PROMs	Note
De Paolis	2015	45 (range unknown)	0	2 (17%)	0	1 (8%) Girdlestone for infection	2 dislocations.	Harris hip score Improved from a pre-op average of 46 to an average of 80 at follow-up.	Conference Abstract (HIP International) 12 cases of THA on irradiated bone, exact indications unknown. Not clearly stated but assumed uncemented as Tantalum implant used.
Kang	2018	62 (20–130)	9 (32%) 7 (1990–2000) 2 (2001–2010)	3 (11%) 1 (1990–2000) 2 (2001–2010)	7 (25%) 5 (of which 3 Girdlestones) (1990–2000) 2 (2001–2010)	10 (36%) 6 + 1 Girdlestone for infection (1990–2000) 4 + 2 Girdlestones (2001–2010)	2 patients died during study period	Visual analogue scale (VAS) and Harris hip score Mean VAS improved from 7.08 pre-op to 3.39 Mean HHS improved from 42 pre-op to 79	31 cases of surgery for hip osteonecrosis after pelvic irradiation. 28 primary THA (considered here), 3 primary resection arthroplasty (not considered). 16 cases (57%) for avascular necrosis of the femoral head. 8 cases (29%) for radiation osteitis. 4 cases (14%) for pathological fracture of the femur/acetabulum. Presented as 2 groups (1990–2000 and 2001–2010), but same method throughout both groups.
Total Uncemented		61	20 (14%)	6 (4%)	15 (10%)	22 (15%)			

Outcome analysis

Total hip arthroplasty failure/revision rate

In total, 24% of the cemented THAs underwent revision (27/111), compared with 15% of uncemented THAs (22/143) ($p = 0.073$).

In terms of those requiring revision for acetabular aseptic loosening, this was 16% (18/111) in the cemented group and 10% (15/143) in the uncemented group ($p = 0.178$).

Aseptic loosening

Acetabular aseptic loosening was reported in 24% of cemented THAs (27/111) and 14% of uncemented THAs (20/143), which was statistically significant ($p = 0.035$). Not all of these went on to have a revision.

Prosthetic joint infection

Prosthetic joint infection was reported in 5% of cemented THAs (5/111) and 4% of uncemented THAs (6/143) ($p = 0.905$).

Patient-reported outcome measures (PROMs)

All of the studies measured some form of PROMs; however, the reporting of these outcomes was very variable, and the lack of numerical data for the cemented group prevented quantitative analysis.

In the cemented group, Massin et al. [10] used the Postel Merle d'Aubigné (PMA) score; however, they did not report any results for their Group 1 (1970–1982) patients and reported outcomes for 11 of their Group 2 (1983–1990) patients, with good or excellent outcome for 9 of these. Felden et al. [12] also used the PMA score, reporting a pre-operative median score of 9 and a final follow-up median score of 15, demonstrating improvement in function.

Cho et al. [11], who included 4 cemented and 14 uncemented cases, used the modified Harris hip score (HHS), but did not report individual outcomes or categorize their patients by the use of cement. They reported an overall result of HHS less than 80 in 67% of patients, suggesting generally poor function.

In the uncemented group, the numerical reporting of PROMs was better, with all of the studies using the HHS or a modified version, with some studies also using other quality-of-life assessment measures. Jacobs et al. [13] reported a change in average HHS from 41 pre-operatively to 82 post-operatively for stable implants, and a change from 47 to 60 for the failed implants. Kim et al. [14] showed improvement in mean HHS from 47 pre-operatively to 90 post-operatively and also demonstrated improvements in quality of life, as measured by the Short-Form Health Survey (SF-36), with a change of 45.1–73.4 for the physical health domain and 65.3–83.7 for the mental health domain. Joglekar et al. [15] showed improvement in mean HHS from 36 pre-operatively to 80 at 5-year follow-up, and De Paolis et al. [16] similarly reported improvement from 46 pre-operatively to 80 at follow-up. Kang et al. [17] showed improvement in mean HHS from 42 pre-operatively to 79 at follow-up and also reported a reduction in pain as measured by the visual analogue scale (VAS), with the mean score ranging from 7.08 to 3.39 following surgery.

Other complications

There were a broad range of other complications reported in each group. Short-term complications in the cemented group included 1 sciatic nerve palsy, 2 phlebitis, 2 haematomas, 7 dislocations, and 2 periprosthetic fractures. The uncemented group reported 3 dislocations and 1 periprosthetic fracture. There were 20 deaths reported in the cemented group and 8 deaths in the uncemented group.

Discussion

Summary of evidence

Revision rate

It would appear that there is a higher overall revision rate in the cemented THA group (24% vs 15%) when considering all forms of revision, which also includes problems with the femoral components; however, this result did not quite reach statistical significance ($p = 0.073$).

In terms of revisions performed specifically for acetabular aseptic loosening, this also appears to be slightly higher in the cemented group (16% vs 10%, $p = 0.178$), but does not take into account the fact that some patients had aseptic loosening but were not revised, in some cases due to dying of another cause. These studies all involved patients with a history of cancer and pelvic irradiation; therefore, it is not surprising that there is a high mortality rate amongst this population. As such, there were several patients who had signs of loosening, but did not have a revision, presumably because the loosening was asymptomatic, or was identified at a time whereby the risks of the operation were felt to outweigh the benefits. Indeed, this is demonstrated clearly in the study by Massin et al. [10], which reported a total of 24 patients with aseptic loosening, but only revised 16 of them.

Aseptic loosening

Overall, aseptic loosening (regardless of revision) was reported as 24% for the cemented group compared with 14% for the uncemented group, and this was a statistically significant result ($p = 0.035$). This is a remarkable finding because it demonstrates very clearly that there is a measurable difference in outcomes between the two types of acetabular components.

However, it must be said that the outcome of revision for aseptic loosening is more meaningful than the total number with aseptic loosening, as it captures the judgement made by the treating surgeon, based on symptoms and functional status of the patient, and therefore serves as a better marker of clinical failure than radiographic signs of aseptic loosening alone.

Of note, the uncemented cohort in our study had higher mean total radiation doses (6129 cGy after exclusion of outliers, compared with 5238 cGy in the cemented group), which should be associated with poorer bone quality, making these findings even more remarkable.

Acetabular reinforcement

Acetabular reinforcement techniques are present throughout both groups in our study, but not universally.

In the cemented group, Massin et al. [10] recommend routinely reinforcing the acetabulum, as they present 2 cohorts of cemented acetabular components: an early group without reinforcement and a later group with reinforcement—the Müller ring in most cases. They reported improved outcomes in their second group and advise that acetabular reinforcement should be used for all cases of THA on an irradiated hip.

Cho et al. [11] reported on a series with mixed methodology, whereby only 4 of their patients underwent cemented THA, and each of these also had acetabular reinforcement with the Müller ring. Out of these 4 patients, 2 showed signs of loosening and 1 required revision, which are relatively unfavourable results.

Felden et al. [12] used the Kerboull cross for acetabular reinforcement alongside cemented arthroplasty for their series, arguing that it decreases the stress applied to periacetabular bone and gives elasticity to the construct. They reported the best outcomes for cemented THAs, with much reduced revision and loosening rates when compared to the previous studies [10, 11].

In the uncemented group, Jacobs et al. [13] reported a series of uncemented arthroplasties done with the Harris-Galante I or II acetabular component (Zimmer Biomet) without reinforcement, and had relatively poor outcomes with 4 out of 9 patients showing signs of aseptic loosening (44%), and 2 patients undergoing revision. The remainder of the patients from the study by Cho et al. [11] underwent uncemented arthroplasty with the Harris-Galante II or Trilogy system (Zimmer Biomet) without reinforcement, again showing relatively poor outcomes with half (7 out of 14) showing signs of aseptic loosening and 6 of these requiring revision, all of which were revised using acetabular reinforcement (4 Müller rings, 2 Ganz rings). Similarly, in the recent study by Kang et al. [17], all patients underwent uncemented arthroplasty with the Harris-Galante II or Trilogy systems (Zimmer Biomet) without reinforcement, and they reported rates of aseptic loosening and all-cause revision each at around one in three (aspetic loosening 32%, revision 36%).

Kim et al. [14] reported a series of patients following uncemented arthroplasty with either PSL (Stryker) or Universal (Biomet), none with acetabular reinforcement. Interestingly, they reported extremely good outcomes, with no patients showing signs of aseptic loosening and only 1 patient requiring revision for acetabular failure. They revised 2 other prostheses due to failure of the femoral component.

In the studies by Joglekar et al. [15] and De Paolis et al. [16], the tantalum (Zimmer) trabecular metal uncemented acetabular component was used. Joglekar et al. [15] reported very successful outcomes with no patients showing signs of aseptic loosening or requiring revision. De Paolis et al. [16] also reported no patients with aseptic loosening, but did have 2 patients (out of 12) with prosthetic joint infection, one of which required revision.

These results suggest that the best results have generally been seen with the studies using the uncemented trabecular metal implants, with the exception of the study by Kim et al. [14], which reported excellent outcomes using standard uncemented acetabular components.

Other complications and mortality

Both cohorts report a similar rate of prosthetic joint infection (cemented 5%, uncemented 4%), and the other reported complications are largely in keeping with the risks of undertaking any form of hip arthroplasty.

On the surface, the mortality figures seem rather different (20 in the cemented group compared with only 8 in the uncemented group), but 19 of these deaths in the cemented group were from one study [12]. All the studies reported different lengths of follow-up and definition of study period, and this particular study presented an impressive follow-up of 10 years, which could explain the higher total number of deaths, particularly in the context of this cohort of patients.

Limitations

It must be recognized that there are several limitations to this study. This review only includes a small number of studies (eight), as this is a poorly reported topic with limited literature. Study heterogeneity is an issue, with these eight studies each having different methodology, and some studies containing subgroups of different methodology and implants used. As a result, the patient characteristics and outcome measures are also likely to have been slightly different between studies.

Additionally, there are some differences that must be commented on relating to patient selection. These studies consider patients that required total hip arthroplasty for hip pathology ranging from degenerative change to radiation osteonecrosis. This clearly suggests that unmeasurable differences will have been present to the underlying bone health which will have affected implant success. However, all patients selected for inclusion in this study had undergone targeted pelvic irradiation (mean total dose of approximately 6000 cGy, depending on adjustment for outliers), with very few patients receiving significantly less radiation than this.

Conclusion

The evidence presented here suggests that overall outcomes are better for uncemented THAs in post-radiotherapy patients, with a significantly lower rate of aseptic loosening and an appreciable (but not statistically significant) reduction in revision rate.

The best outcomes seem to be associated with the use of acetabular reinforcement across both cemented and uncemented groups. The two studies reporting outcomes with trabecular metal components demonstrated particularly promising results; however, we acknowledge this represents a small number of patients and currently represents a limited body of evidence.

Further work is needed in order to further evaluate the differences in outcomes associated with implant choice when operating on irradiated hips.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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