Reconstruction of the hip after resection of periacetabular oncological lesions

A SYSTEMATIC REVIEW

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Aims
Reconstruction of the acetabulum after resection of a periacetabular malignancy is technically challenging and many different techniques have been used with varying success. Our aim was to prepare a systematic review of the literature dealing with these techniques in order to clarify the management, the rate of complications and the outcomes.

Patients and Methods
A search of PubMed and MEDLINE was conducted for English language articles published between January 1990 and February 2017 with combinations of key search terms to identify studies dealing with periacetabular resection with reconstruction in patients with a malignancy. Studies in English that reported radiographic or clinical outcomes were included. Data collected from each study included: the number and type of reconstructions, the pathological diagnosis of the lesions, the mean age and follow-up, gender distribution, implant survivorship, complications, functional outcome, and mortality. The results from individual studies were combined for the general analysis, and then grouped according to the type of reconstruction.

Results
A total of 57 studies met the inclusion criteria and included 1700 patients. Most lesions were metastatic (41%), followed by chondrosarcoma (29%), osteosarcoma (10%), Ewing’s sarcoma (7%), and multiple myeloma (2%). The techniques of reconstruction were divided into seven types for analysis: those involving a Harrington reconstruction, a saddle prosthesis, an allograft and allograft prosthesis composite, a pasteurised autograft, a porous tantalum implant, a custom-made prosthesis and a modular hemipelvic reconstruction. The rate of complications was 50%, with infection (14%) and instability (8%) being the most common. Mortality data were available for 1427 patients (84%); 50% had died of disease progression, 23% were alive with disease, and 27% had no evidence of disease at a mean follow-up of 3.4 years (0 to 34).

Conclusion
Both the rate of complications and mortality are high following resection of oncological periacetabular lesions and reconstruction. Many types of reconstruction have been used with unique challenges and complications for each technique. Newer prostheses, including custom-made prostheses and porous tantalum implants and augments, have shown promising early functional and radiographic outcomes.

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soft-tissue loss following resection of the tumour, perioperative complications and the post-operative treatment of the tumour or its progression. Previous authors have reported high complication rates and marginal functional results with early reconstructive techniques.\textsuperscript{13}

In an effort to understand the burden of the condition and the surgical complications, mid-term component, patient survivorship and functional outcomes of different reconstruction techniques, we aimed to perform a systematic review of the literature on reconstruction of the hip after resection of oncological periacetabular lesions.

**Patients and Methods**

In March 2017, a search of PubMed and MEDLINE was conducted for English language articles published between January 1990 and February 2017. Combinations of the terms “pathologic”, “metastatic”, “oncologic”, “tumor”, “neoplasm”, “limb salvage”, “hip arthroplasty”, “hip reconstruction”, “acetabular reconstruction”, and “pelvic reconstruction” were used. The reference lists of the resulting articles were reviewed for inclusion. Inclusion criteria were: studies published in English; gender of patients of all ages; human studies; studies that reported radiographic or clinical outcomes; all levels of evidence; and studies reporting clinical outcomes for total hip arthroplasty (THA) in patients with a pathological lesion involving the hip. Exclusion criteria were: studies with patients who had outcomes included in an earlier study; non-clinical studies and studies that involved pathological lesions that were diagnosed following THA. All studies were reviewed by two authors (TSB, CGS).

The initial search yielded 1674 studies (Fig. 1). Following review of their titles, the full text of 133 were studied. After removing review articles, those dealing with femoral reconstruction for malignancy, those that involved resection alone as treatment and articles that did not separate outcomes based on type of reconstruction, 57 studies remained for the final analyses (Fig. 1).\textsuperscript{1,4-12,14-60}
The data were collected after a review of the design, the number of patients and risk of bias within each study. All were retrospective case series. The following data were collected from each study: the number and type of reconstruction, the pathology of the lesions, the mean age of the patients and range, the gender of patients, the mean follow-up and range, implant survivorship, the incidence and types of complication, the functional outcome scores and mortality. The results from the individual studies were combined as a whole for the analysis. Then, after grouping the studies according to the type of reconstruction, the demographic, clinical and functional data were combined for each type. Although mortality data can be a reflection of the oncological diagnosis and initial resection rather than the type of reconstruction, these data were included in the discussion of each technique. Musculoskeletal Tumor Society (MSTS) functional scores were used in most studies and were therefore used in this review to combine and compare functional outcomes.

**Results**

In the 57 studies reviewed, a total of 1700 reconstructions were performed. The mean age at the time of reconstruction was 49 years (5 to 92). There were 829 male patients (49%). The pathology was osseous metastatic disease in 700 (41%), chondrosarcoma in 487 (29%), osteosarcoma in 169 (10%), Ewing’s sarcoma in 111 (7%), multiple myeloma in 26 (2%), and other or not specified in 207 (11%) (Table I).

Data about mortality were available for 1427 reconstructions (84%). At a mean follow-up of 3.4 years (0 to 34), 710 (50%) had died of progression of disease (DOD), 326 (23%) were alive with evidence of disease (AWD), and 391 (27%) had no evidence of disease (NED) (Table II).

There were 857 complications (50%) in the 1700 reconstructions. Deep prosthetic joint infection was the most common, occurring in 228 patients (14%). Dislocation occurred in 144 patients (8%). Problems with wound healing occurred in 105 patients (6%), nerve palsy in 52 (3%) and thrombosis in 32 (2%) (Table II).

A Harrington-type reconstruction was used in 14 studies, involving 415 patients.
were performed for metastatic disease. The mean age was 62 years (15 to 92). There were 189 male patients (46%). The mean follow-up was 1.4 years (0 to 9.3). The mean MSTS functional score was 61% in the surviving patients at the final follow-up, at which time 288 patients (69%) were DOD and 89 (21%) were AWD. Dislocation was the most common complication, occurring in 35 patients (8%), followed by deep infection occurring in 22 (5%), aseptic loosening in nine (2%), periprosthetic fracture in six (1%), thrombosis in five (1%), and nerve palsy in five (1%) (Table III).

A saddle prosthesis was used in eight studies, involving 135 patients.\textsuperscript{9,23,25,29-31,43,48} Most, 103 (76%), were for a primary malignancy. The mean age was 53 years (17 to 79). There were 78 male patients (58%). The mean follow-up was 4.6 years (0.1 to 16.8). The mean MSTS functional score was 51% in the surviving patients at the final follow-up, at which time 64 patients (47%) were DOD, 43 (32%) had NED, and 11 (8%) were AWD. Deep infection was the most common complication, occurring in 32 patients (24%). Dislocation occurred in 22 patients (16%), nerve palsy in ten (7%), prosthetic dissociation or failure in eight (6%), periprosthetic fracture in eight (6%), thrombosis in seven (5%), and problems with wound healing in four (3%) (Table IV).

Allograft and allograft prosthesis composite reconstructions were used in nine studies, involving 133 patients.\textsuperscript{7,14,19,22,24,26,43,50,54} Most, 123 (93%), were for a
primary malignancy. The mean age was 42 years (5 to 71). There were 84 male patients (63%). The mean follow-up was 5.8 years (0.8 to 19). The mean MSTS functional score in the surviving patients at final follow-up was 72%. At this time, 37 patients (28%) were DOD, 55 (41%) had NED and eight (6%) were AWD. Deep infection was the most common complication, occurring in 20 patients (15%). Local recurrence occurred in 15 (11%), dislocation in ten (8%), problems with wound healing in seven (5%), prosthesis migration or failure in six (5%), and late allograft fracture in five (4%) (Table V).

Autograft reconstructions were used in five studies, involving 54 patients.8,14,27,33,60 In this technique, the resected hemipelvis is pasteurised with heat to sterilise the malignancy and re-implanted with plates, screws, and prostheses. Most, 47 (87%), were for a primary malignancy. The mean age was 41 years (13 to 65). There were 27 male patients (50%). The mean follow-up was 5.2 years (0.7 to 11.8). The mean MSTS functional score in the surviving patients at final follow-up was 72%, at which time 18 patients (33%) were DOD, 30 (56%) had NED and six (11%) were AWD. Dislocation was the most common complication, occurring in eight patients (15%). Deep infection occurred in five (13%), aseptic loosening in four (10%), late graft fracture in four (10%), local recurrence in three (6%) and problems with wound healing in two (5%) (Table VI).

### Table V. Results of allograft reconstruction

| Studies, n | 9 |
| Reconstructions, n | 133 |
| Metastatic disease, n (%) | 10 (7) |
| Primary malignancy, n (%) | 123 (93) |
| Mean age in yrs, n (range) | 42 (5 to 71) |
| Male patients, n (%) | 63 (63) |
| Mean follow-up in yrs, n (range) | 5.8 (0.8 to 19) |
| MSTS score at final follow-up, % | 72 |

### Patient mortality, n (%)

- AWD: 8 (6) |
- NED: 55 (41.4) |
- DOD: 37 (27.8) |

### Complications, n (%)

- Infection: 20 (15) |
- Local recurrence: 15 (11) |
- Dislocation: 10 (8) |
- Wound necrosis: 7 (5) |
- Prosthesis migration/failure: 6 (5) |
- Fracture: 5 (4) |

### Table VI. Results of autograft reconstruction

| Studies, n | 5 |
| Reconstructions, n | 54 |
| Metastatic disease, n (%) | 7 (13) |
| Primary malignancy, n (%) | 47 (87) |
| Mean age in yrs, n (range) | 41 (13 to 66) |
| Male patients, n (%) | 27 (50) |
| Mean follow-up in yrs, n (range) | 5.2 (0.7 to 11.8) |
| MSTS score at final follow-up, % | 72 |

### Patient mortality, n (%)

- AWD: 6 (11) |
- NED: 30 (56) |
- DOD: 18 (33) |

### Complications, n (%)

- Dislocation: 8 (15) |
- Infection: 5 (13) |
- Aseptic loosening: 4 (10) |
- Late graft fracture: 4 (10) |
- Local recurrence: 3 (6) |
- Wound healing: 2 (5) |

MSTS, Musculoskeletal Tumor Society; AWD, alive with disease; NED, no evidence of disease; DOD, dead of disease
Porous tantalum implants were used in two recent studies, involving 30 patients. Most, 22 (73%), were for a primary malignancy. The mean age was 58 years (22 to 80). There were six male patients of the ten reported by gender (60%). The mean follow-up was 4.7 years (0.7 to 9.4), at which time the mean Harris Hip Score in the surviving patients was 74. At final follow-up, one patient (3%) had DOD and 21 (70%) were AWD. Implant survivorship free from all-cause revision was 100%. Dislocation was the most common complication occurring in four patients (13%). Superficial infection occurred in two (7%), thrombosis in two (7%), bleeding complications in two (7%), and problems with wound healing in one (3%) (Table VII).

Custom endoprostheses were used in five studies, involving 182 patients. Most, 156 (86%), were for a primary malignancy. The mean age was 42 years (10 to 81). There were 87 male patients (48%). The mean follow-up was 4.4 years (0.2 to 33.5). The mean MSTS functional score in the surviving patients at final follow-up was 63%. Implant survivorship from all-cause revision was 61% at final follow-up. Deep infection was the most common complication occurring in 42 patients (23%). Local recurrence occurred in 40 (22%) and dislocation in 31 patients (17%) (Table VIII).

Modular hemipelvis reconstructions were used in five studies, involving 143 reconstructions. Most, 112 (78%), were for a primary malignancy. The mean age was 47 years (12 to 81). There were 84 male patients (59%). The mean follow-up was five years (0.8 to 23.8). The mean MSTS functional score in the surviving patients at final follow-up was 69%, at which time, 28 patients (20%) were DOD, 50 (35%) were AWD and 31 (22%) had NED. Once again, deep infection was the most common complication, occurring in 34 patients (24%). Dislocation occurred in 18 (13%), local recurrence in 16 (11%), aseptic loosening in six (4%) and problems with wound healing in three (2%) (Table VIII).

**Discussion**

Periacetabular oncological lesions may present in various areas of the acetabulum and be of varying size. Many types of reconstruction are available for their treatment. Our aim in this systematic review was to present the largest and most comprehensive review of acetabular reconstruction after resection of these lesions, in order to aid their management and to clarify the clinical outcomes.

Foremost, we found that most periacetabular lesions were from metastatic disease (41%), followed by chondrosarcoma (29%), osteosarcoma (10%), and Ewing’s sarcoma (7%). The mean age of the patients, of 49 years, was younger than that of most patients who undergo THA, median age 69 years. Importantly, this review provides a historical perspective on reconstructive techniques that may no longer be frequently encountered. One technique, the Harrington-type reconstruction, has been used exclusively in metastatic disease for palliative pain relief, whereas all other techniques are predominately used for primary malignancies. While the overall rate of complications in all the studies was 50%, deep infection (14%) and dislocation (8%) were the most common complications. Further developments should focus on decreasing these complications and this might involve the use of vancomycin powder and dual-mobility constructs respectively.

Henderson et al described the mechanisms of failure of endoprostheses as being either mechanical, due to soft-tissue failure, aseptic loosening or structural failure, or non-mechanical due to infection or progression.
of disease. While it was difficult to separate complications from revisions in this review, future studies should strive to describe implant survivorship using these guidelines.

There are limitations to this study. Foremost, the data presented are retrospective. Moreover, the demographic data and pre-operative diagnoses were heterogenous which had an impact on the rates of complication and long-term outcomes.

Reconstruction after resection of an oncological periacetabular lesion is technically challenging. The evidence presented in this review can guide the discussion with patients during pre-operative planning. Newer techniques, including custom-made prostheses and reconstruction with porous tantalum acetabular implants and augments offer promising early results.

**Take home message:**
- Hip reconstruction should be considered for most periacetabular lesions that present to the orthopaedic surgeon in 2017.
- Metastatic lesions predominate, followed by chondrosarcoma, osteosarcoma, Ewing’s sarcoma, and other primary bone tumours.
- Multiple methods for reconstruction are available, each with its own risks and benefits.
- Overall complication rate is high, but implant survivorship is improved with newer technology and improved methods of reconstruction.

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**Table VIII. Results of custom prostheses reconstruction and modular endoprosthesis reconstruction**

| Study                           | Custom prostheses reconstruction | Modular endoprosthesis reconstruction |
|---------------------------------|----------------------------------|---------------------------------------|
| **Studies, n**                  | 5                                | 5                                     |
| **Reconstructions, n**          | 182                              | 143                                   |
| **Metastatic disease, n (%)**   | (26 (14))                        | (31 (22))                             |
| **Primary malignancy, n (%)**   | (156 (86))                       | (112 (78))                            |
| **Mean age in yrs, n (range)** | (42 (10 to 81))                  | (47 (12 to 81))                       |
| **Male patients, n (%)**        | (88 (48))                        | (84 (58))                             |
| **Mean follow-up in yrs, n (range)** | (4.4 (0.2 to 33.5)) | (5 (0.8 to 23.8))                     |
| **MSTS score, %**               | 63                               | 64                                    |
| **Patient mortality, n (%)**    |                                   |                                       |
| AWD                             | 75 (41)                          | 50 (35)                               |
| DOD                             | 63 (35)                          | 28 (20)                               |
| NED                             | 31 (19)                          | 31 (22)                               |
| **Implant survivorship from all-cause revision at final follow-up, %** | 61 | 69 |
| **Complications, n (%)**        |                                   |                                       |
| Infection                       | 41 (23)                          | 34 (24)                               |
| Local recurrence                | 40 (22)                          | 18 (13)                               |
| Dislocation                     | 31 (17)                          | 16 (11)                               |
| Thrombotic complication         | 11 (6)                           | 6 (4)                                 |
| Wound healing                   | 10 (5)                           | 6 (3)                                 |
| Nerve palsy                     | 6 (3)                            | 2 (1)                                 |
| Aseptic loosening               |                                  |                                       |

MSTS, Musculoskeletal Tumor Society; AWD, alive with disease; DOD, dead of disease; NED, no evidence of disease.
Author contributions:
T. S. Brown: Data analysis, Writing the paper.
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