CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 459, pp. 122–127

Outcomes of an Anatomically Based Approach to Metastatic Disease of the Acetabulum

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Metastatic disease of the acetabulum is a common and challenging surgical problem. We asked whether acetabular reconstruction for metastatic bone disease improves functional outcome with an acceptable risk of surgical morbidity. We also asked if primary tumor type and the presence of visceral metastases predicted patient survival. We analyzed prospectively accumulated records of 62 consecutive patients who underwent 63 hip arthroplasties with acetabular reconstruction. Operative technique was guided by the extent of dome and column involvement. Demographics, functional status in the form of the Eastern Cooperative Oncology Group (ECOG) score, and survival data were analyzed. Functional scores improved from an average of 2.6 preoperatively to 1.1 postoperatively. Four patients had postoperative complications for which we performed further surgery. Mean survival for the patients with breast cancer was longer at 21 months compared to 9 months for the patients with other primary malignancies. Patients who did not present with visceral metastases had longer survival than those with visceral metastases. Despite the moderate risk of operative complications, an anatomically based approach to reconstruction of acetabular defects from metastatic disease improves functional outcome. Breast cancer as the primary malignancy and the absence of visceral metastases predicted longer survival.

Level of Evidence: Level II, prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

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DOI: 10.1097/BLO.0b013e31803ea9c8

Advanced metastatic disease to the acetabulum is a debilitating problem for the cancer patient and a technical challenge for the orthopaedic surgeon. Patients present with substantial pain and have physical limitations due to their inability to weight-bear on the affected side. Extensive disease compromises the mechanical stability of the weight-bearing areas of the acetabular dome and the supportive anterior and posterior columns of the pelvis. Systemic chemotherapy, bisphosphonates, hormonal treatment, and/or local irradiation can often help control the disease process. However, palliative surgical management is eventually considered in approximately 15% of patients with bone metastases.[13,14]

The decision to operate on a patient with metastatic disease to the acetabulum depends on many factors. We believe patients who are refractory to nonoperative management and who are expected to survive longer than the surgical recovery time are reasonable surgical candidates.[2] However, patient comorbidities also play a role, as do the preoperative functional, nutritional, and immune status of the patient.[7] Although several studies have discussed the technical feasibility of acetabular reconstruction for metastatic disease,[4,10–12,16] studies that identify preoperative factors predicting life expectancy in this patient population are few.[6,9] Surgical procedures that specifically address the acetabular dome and column deficiencies allow for the tailoring of surgical reconstruction in this patient population.[4,6]

The ECOG performance status is a commonly used system for determining functional condition and predicting survival in cancer patients.[7] The ECOG scores range from 0 (normal function) to 4 (completely bed bound). A score of 1 indicates minimal functional impairment and scores of 2 and 3 indicate impairment leading to less than 50% time in bed or more than 50% time in bed, respectively. The goal of surgical reconstruction is immediate improvement in functional ability (at least one point on the ECOG score) so patient mobilization and independence are possible.

We asked the following questions: (1) Does acetabular reconstruction for metastatic bone disease improve functional outcome by at least one level on the ECOG performance status scale? (2) Is there a high risk of surgical morbidity? (3) Are primary tumor type and the presence of visceral metastases predictive of patient survival?

MATERIALS AND METHODS

We identified all patients who underwent acetabular reconstruction and total hip arthroplasty for metastatic disease between September 1996 and December 2005 from a prospectively collected database. There were 62 patients who underwent 63 reconstructions. One patient with bilateral disease underwent two separate procedures and had two separate entries into the database. Patients with ipsilateral proximal femoral disease were only included if acetabular disease was present as determined by preoperative studies and intraoperative verification. Operative indications included intractable pain unresponsive to systemic or radiation treatment, poor functional status, progression of structural instability such as medial head migration despite implementation of multimodality treatment, and inability to weightbear. Surgery was contraindicated in patients expected to survive less than 6 weeks. Patients were followed postoperatively at regular intervals with clinical exams and radiographs. With Research Ethics Board approval, patient charts were also reviewed to complete missing data.

Clinical variables analyzed included patient age at the time of surgical consultation; gender; primary tumor diagnosis; time from diagnosis of primary tumor to surgical treatment of the acetabular metastasis; presence of other skeletal metastases; presence of visceral metastases; anatomic extent of disease; pre- or postoperative radiation treatment; preoperative performance status in the form of the Eastern Cooperative Oncology Group (ECOG) score; maximum postoperative performance status; type of reconstruction; surgical complications (defined as those requiring repeat surgery) and management; perioperative death; survival status; and time to death or date of last followup.

The database included 14 male and 49 female patients with a mean age of 62 years (range, 39–85 years). Mean time from diagnosis of the primary tumor to surgical management of the acetabulum was 50 months (range, 0–196 months). The most common primary diagnosis was breast cancer (41 patients, 65%), followed by lung cancer (six patients, 10%), and renal carcinoma (four patients, 6%). Other primaries included multiple myeloma (three patients), prostate cancer, squamous cell carcinoma, transitional cell carcinoma, and gastrointestinal cancer (two patients each). There was one case of an unknown primary. Other skeletal metastases were present in 57 (91%) of the patients, and 19 patients (30%) presented with visceral metastases.

Preoperative Judet views and/or a CT scan of the pelvis were used to determine the extent of disease and bone loss. A modified version of the American Academy of Orthopaedic Surgeons (AAOS) classification system for acetabular bone loss was used to categorize the extent of disease and to determine the reconstruction required.[3] The final reconstructive decision was made intraoperatively once the precise extent of disease was determined.

We modified the AAOS classification and assigned operative approaches according to the defect type (Table 1). Type I defects are segmental or cavitary with an intact acetabular dome, and intact anterior and posterior column integrity. Following tumor curettage, these defects require a cemented hip arthroplasty cup with cement plug anchoring as described by Williams et al.[15] Type II defects are medial wall defects with intact columns and can be reconstructed with an antiprotrusio cage and cementation or bone grafting of the medial wall (Fig 1). Type III defects are combined dome and column defects with an intact posterior column. These defects require reconstruction with a roof ring with or without long retrograde screws into solid bone high in the ilium. A reconstruction cage and longer retrograde screws are needed with substantial dome defects and tenuous columns. A roof ring, instead of a cage, will suffice if column stability is not tenuous intraoperatively. This type of reconstruction transmits the weight-bearing forces of the hip to structurally stable bone as previously described by Harrington.[4] Type IV defects indicate pelvic discontinuity requiring the addition of antegrade Steinmann pins through the iliac wing into the ischium and/or the anterior column as previously described by others.[6,12] In this type of reconstruction, the columns are stabilized first and a cage

TABLE 1. Anatomic Classification of Acetabular Deficiency for Metastatic Bone Disease

Type of Acetabular Defect	Reconstruction
Type I Segmental or cavitary with intact acetabular dome and anterior and posterior columns	Cemented acetabular cup with cementation of defects
Type II Medial wall disease	Antiprotrusio cage with or without bone grafting or cementation of the medial wall
Type III Combined acetabular dome and column disease Posterior column is structurally intact	Roof ring with retrograde screws into intact iliac wing Reconstruction cage for tenuous columns
Type V Pelvis discontinuity Posterior column integrity disrupted	Reconstruction cage and antegrade Steinmann pins

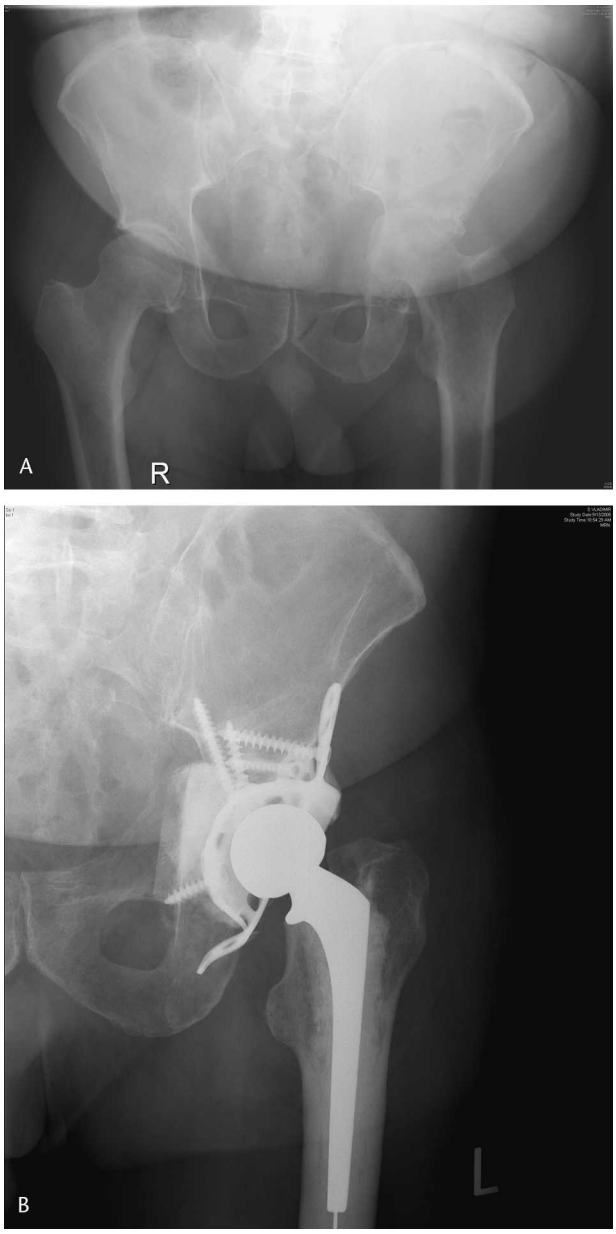

Fig 1A–B. A 71-year-old male patient with multiple myeloma had severe left hip pain and was unable to bear weight on the left side. (A) An anteroposterior (AP) radiograph of the pelvis shows medial wall deficiency and protrusion of the left femoral head into the pelvis. Anterior column disease is also present. (B) The postoperative AP radiograph of the pelvis shows hip reconstruction with an antiprotrusio cage, cementation, and medial wall bone grafting. The femur is reconstructed with a standard cemented prosthesis.

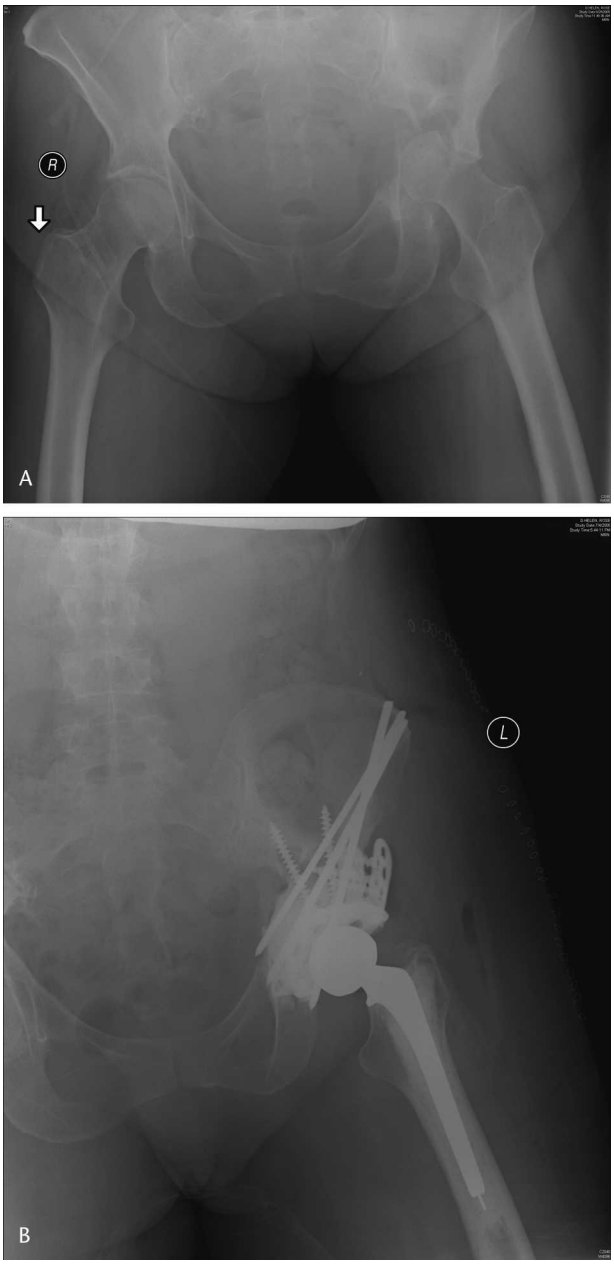

Fig 2A–B. A 50-year-old female with metastatic squamous cell carcinoma of the cervix presented with left hip pain refractory to local irradiation and systemic management. (A) An AP radiograph of the pelvis shows severe acetabular dome and posterior column disease resulting in pelvic discontinuity. (B) The postoperative AP radiograph of the pelvis shows acetabular reconstruction with a roof ring, retrograde long screws into the ilium, and antegrade Steinmann pins from the ilium into the anterior and posterior columns.

is then used to transfer forces across the construct (Fig 2). The most common types of acetabular bone deficiency were type III (extensive dome and column disease) in 28 patients (44%) and type II (medial wall deficiency) in 19 patients (30%). Only seven patients (11%) had pelvic discontinuity.

All procedures were performed through an extended lateral approach to the hip.[8] Trochanteric osteotomies were discontinued early in the study period due to problems with nonunion and instability. In order to obtain enough exposure to seat the iliac

flange when a roof ring or cage was used, the abductors were carefully dissected off the ilium with concern not to denervate these muscles. The ischial phalange was impacted into a trough in the ischium.

Surgical complications were defined as events that required operative management. Perioperative death was defined as death occurring within 1 month postoperatively or during the index hospital stay. For analysis purposes, the one case of bilateral disease was categorized as two separate cases.

We considered the prescription of bisphosphonates as standard care in addition to appropriate chemotherapeutic and/or hormonal regimens for the primary tumors. Forty-nine patients (78%) received preoperative radiation to the operative site and nine patients (14%) received postoperative radiation. The other five patients (8%) did not receive perioperative radiation.

Preoperative ECOG scores averaged 2.6 (standard deviation, 0.9) for 59 patients (data was not available for four patients). Most patients (44 patients, 70%) were scored at 2 or 3 (impairment requiring time in bed during waking hours). Eleven patients (18%) were fully bedridden preoperatively. Assuming the mean and standard deviation of ECOG score in patients with advanced metastatic disease is 2.6 and 0.9, we would need a sample size of 55 to produce a 95% confidence interval (CI) to detect a 1-point improvement with a precision of ± 0. 15 in ECOG score after reconstruction surgery.

We performed descriptive analysis to summarize patient demographics and the occurrence of surgical complications. Categorical data were reported as percentages and continuous data as a mean and standard deviation. Pre- and postoperative functional scores were compared using t test or Wilcoxon rank-sum test after testing for normal distribution (Kolmogorov-Smirnov test). Survival for each patient was calculated from the time of surgery to the time of death or last outpatient visit. Probability curves were constructed with the Kaplan-Meier method and were compared with the log-rank test. The survival data were analyzed separately for patients with primary breast tumors, other primary tumors, and patients with and without visceral metastases. Mean survival time and 95% confidence intervals (CI) are reported. All p values were two-sided ($p < 0.05$). Data were analyzed using Minitab version 14.0 (Minitab Inc, State College, PA) and SPSS statistical software version 11.5 (SPSS Inc, Chicago IL).

RESULTS

The average postoperative ECOG score of 1.1 (standard deviation 0.7) was improved ($p < 0.001$) over the average preoperative ECOG score of 2.6 (standard deviation 0.9). Therefore we found acetabular reconstruction improves functional outcome by at least one point on the ECOG scoring system. Seven patients (11%) had postoperative ECOG scores of 0 (no functional impairment), 38 patients (60%) had ECOG scores of 1 (minor functional limitations) and eight patients (13%) had ECOG scores of 2 (some impairment requiring less than 50% of waking hours in bed). Only one patient remained bed bound. Postoperative data was unavailable for nine patients.

We had two (3%) perioperative deaths and four (6%) complications for which further surgery was performed: two hip dislocations, one fracture of the greater trochanter, and one fracture of the ilium leading to failure of fixation. Disease progression around the construct was noted in four patients (6%) and treated nonoperatively.

At the time of writing, 14 patients (22%) were alive with evidence of disease at a mean followup of 13 months. Forty-six patients (73%) are dead of disease, two have died of other causes and the status of one patient is unknown. Mean survival time in the entire patient population was 20 months (95% CI: 15.0, 25.5). The overall survival rate was 3.6% (CI: 0.0, 1.0) at 60 months (Fig 3).

Patients with breast cancer had longer ($p = 0.001$) survival at 18 months (56.8%, CI: 41.0, 73.0) and 60 months (5.9%, CI: 0.0, 1.7) compared to those with other malignancies at 18 months (6.7%, CI: 0.0, 1.9) and 57 (0% months) (Fig 4). Similarly, those patients who did not present with visceral metastases had longer ($p = 0.046$) survival (27.5%; CI: 12.0, 43.0 at 34 months and 5.1%; CI: 0.0, 1.5 at 60 months) than those with visceral metastases (7.9%; CI: 0.0, 2.2 at 34 months and 0% at 36 months) (Fig 5).

DISCUSSION

Acetabular reconstruction for metastatic bone disease is a challenging endeavor with the potential to improve patient function. The risk of perioperative morbidity should be assessed prior to embarking on these procedures. Patient factors may predict longer postoperative survival. We therefore asked whether an anatomically based approach to metastatic disease of the acetabulum would lead to functional improvement of at least one point on the ECOG performance status scale and minimize complications in end-stage cancer patients. We also intended to determine if

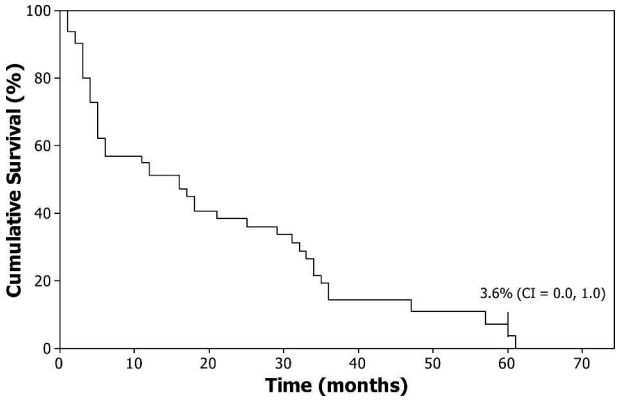

Fig 3. The cumulative survival of patients with acetabular reconstruction for metastatic bone disease is shown.

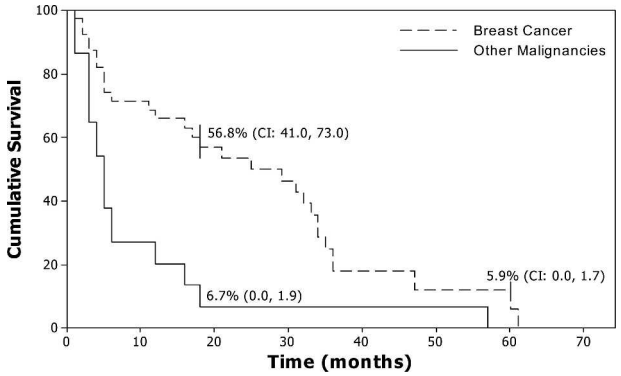

Fig 4. Cumulative survival of patients with acetabular reconstruction for metastatic bone disease by primary tumor type (breast primary versus other primary) is shown. Patients with breast cancer primaries experienced longer survival than those with other primaries.

a primary tumor diagnosis of breast cancer and the absence of visceral metastases at presentation would predict improved postoperative life expectancy.

Our study has several limitations. The patient population is heterogeneous in patient comorbidities and individual chemotherapeutic regimens. Survival data could, therefore, be confounded by the lack of patient stratification based on these factors, which would have left only a handful of patients in each subgroup. In addition, the time points in which postoperative ECOG scores were obtained were not standardized. Patients were followed at regular postoperative intervals, however, the ECOG score recorded is the highest score achieved postoperatively from the first postoperative visit until the last recorded followup. Finally, several patients had missing ECOG scores as indicated in the results section. On the other hand, the data was prospectively accumulated and we report a relatively large population.

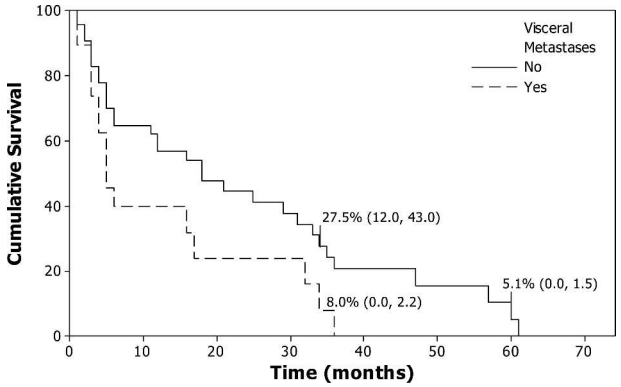

Fig 5. Cumulative survival of patients with acetabular reconstruction for metastatic bone disease by the presence of visceral metastases at presentation is shown. Patients without visceral metastases experienced longer survival.

The technical aspects of acetabular reconstruction for metastatic disease were first described in detail by Harrington[4] in 1981. The author described the use of long retrograde screws to anchor the cemented acetabular cup into structurally intact iliac bone. Antegrade Steinmann pins directed from the iliac crest into acetabular deficiencies were first described in four patients by Walker.[12] Marco et al[6] further clarified the procedure and reported results in 55 patients. The latter study also elaborated on an anatomic classification of metastatic pelvic and acetabular deficiencies first introduced by Wright and Schwartz.[16]

The systematic anatomic approach adopted from these previous studies resulted in most of our patients not requiring a separate incision over the iliac crest for insertion of antegrade Steinmann pins. Instead, over 90% of the patients in the current study were reconstructed with either a standard cemented cup, a protrusio cage for medial wall deficiency, or Harrington reconstruction (long retrograde screws through the ring or cage). We had a low rate of surgical complications. Only four patients (6%) underwent surgery for a postoperative complication, which is approximately half of that reported by the next larger series by Marco et al[6] and Vena et al,[11] both of which report surgical complications of approximately 10%.

The extended lateral approach used likely contributed to our low dislocation rate (3%) compared to other studies in the literature reporting 10% to 42%.[10,11] Particular attention to ensuring continuity of the abductor mechanism and the evolution of larger femoral head components allowed us to avoid dislocations in the latter half of the study. Our local failure rates may have also been low due the majority of cases not being considered surgically emergent and a course of adjuvant radiation, bisphosphonates, and/or systemic therapy was almost always implemented prior to reconstruction. This preoperative time lapse, which was usually 2 to 4 weeks, allowed a better understanding of each patient's disease process. Patients with disease that appeared more indolent did not have as aggressive a reconstruction as those with disease that progressed quickly over this preoperative time course. Therefore, in patients where local failure was anticipated, greater preemptive stability was created during surgery.

The mean survival time in our patient population was 20 months, which is within the range reported by previous studies.[6,9,12] We also found a primary tumor diagnosis of breast cancer and the absence of visceral metastases at presentation predicted longer postoperative survival. These findings are consistent with those reported in the literature, likely due to the improved adjuvant hormonal and chemotherapeutic management in breast cancer patients.[1,6,9] Nathan et al[7] reported prognostic factors in a large patient population that underwent surgery for patho-

logic fractures due to metastatic disease in all skeletal sites. The authors concluded independent predictors of survival were a primary diagnosis of renal cell carcinoma, preoperative ECOG status, single versus bone metastases, and the absence of visceral metastases. Among our patients, renal cell carcinoma as a primary malignancy did not predict longer survival. The pelvic location of metastatic disease in renal cell carcinoma patients may indicate a poorer prognosis compared to appendicular disease.[5]

The improvement in postoperative functional status we report is consistent with other reports in which the majority of patients are able to walk independently in the community at some point during the postoperative survival period.[6,10–12]

The goals in surgical management of symptomatic and refractory metastatic disease to the acetabulum are palliation and restoration of function. An anatomically based approach to acetabular reconstruction allows the orthopaedic surgeon to successfully restore mechanical stability to the affected hip and pelvis and minimize morbidity to the patient. Independent ambulation is achieved in most patients and the reconstruction is durable for the survival period in the majority of patients. Although mean survival is approximately 1 year in most series, quality of life is improved. Multidisciplinary care with medical oncology, radiation oncology, and palliative care medicine is required to help control local disease progression and assist with quality-of-life issues. Finally, careful patient selection is essential. Patients with breast cancer and those without visceral metastases at presentation are most likely to benefit from these procedures over a longer survival period.

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