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Assessing Pain and Functional Outcomes of Percutaneous Stabilization of Metastatic Pelvic Lesions via Photodynamic Nails

A Bi-Institutional Investigation of Orthopaedic Outcomes

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Background: Minimally invasive surgical interventions for metastatic invasion of the pelvis have become more prevalent and varied. Our group hypothesized that the use of percutaneous photodynamic nails (PDNs) would result in decreased pain, improved functional outcomes and level of ambulation, and decreased use of opioid pain medication.

Methods: We performed a retrospective chart review of patients with metastatic pelvic bone disease undergoing stabilization with PDNs (IlluminOss Medical) at 2 institutions. Functional outcome measures assessed include the Combined Pain and Ambulatory Function (CPAF), Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function, and PROMIS Global Health-Physical. Pain was assessed using a visual analog scale (VAS). Outcomes were assessed preoperatively and at 6 weeks, 3 months, 6 months, and 1 year following surgery.

Results: A total of 39 patients treated with PDNs were included. No cases of surgical site infection or implant failure were identified. The median pain VAS score decreased from 8 preoperatively to 0 at the 6-week time point ($p < 0.0001$). The median CPAF score improved from 5.5 points preoperatively to 7 points at the 3-month mark ($p = 0.0132$). A significant improvement in physical function was seen at 6 months in the PROMIS Physical Function ($p = 0.02$) and at both 6 months ($p = 0.01$) and 1 year ($p < 0.01$) for the PROMIS Global Health-Physical. The rate of patients prescribed opioid analgesia dropped from 100% preoperatively to 20% at 6 months following surgery ($p < 0.001$). By 6 weeks, all patients were fully weight-bearing and able to walk independently with or without assistive devices.

Conclusions: Percutaneous stabilization of metastatic periacetabular defects using PDNs is a safe and effective palliative procedure that has been shown to improve patient mobility and provide early pain relief.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Metastatic bone disease is a pathological process that can severely impact patient mobility, functionality, and quality of life. Regardless of sex and age, bone consistently remains the third-most common location for metastatic disease, after the lungs and liver[1]. According to the American Cancer Society, more than $12.6 billion are spent annually in the treatment of skeletal metastases, underscoring a notable economic strain on the U.S. health-care system[2,3].

Metastatic lytic lesions in the periacetabular region cause destruction of the osseous columns of the acetabulum and are associated with an increased risk of pathological fracture, pain with axial loading, and mechanical instability. Surgical intervention is warranted when mechanical structural stability is compromised, and treatment centers around reconstructing the bone defect in the affected area while reinforcing the entirety of the affected columns. Reinforcement of the affected bone has

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been traditionally achieved with Steinmann pins, inserted in either an antegrade or retrograde fashion. In general, surgical stabilization of the pelvis is combined with local control strategies, such as excision and curettage, ablation techniques, and adjuvant radiation treatment[4-6]. Depending on the degree of joint involvement, the additional performance of total hip arthroplasty (THA) may be required.

Presently, there are no universal clinical guidelines for the treatment of unstable periacetabular lesions or the intramedullary stabilization of the pelvic girdle region. Available surgical interventions include traditional open procedures such as the Harrington technique, modular reconstructions with tantalum augments or custom-made implants, and less-invasive procedures such as radiofrequency ablation combined with percutaneous cementoplasty or the use of periacetabular screws[6-8]. Photodynamic nails (PDNs) are a minimally invasive percutaneous technology consisting of patient-conforming, light-sensitive polymer implants. PDNs are particularly helpful in metastatic bone disease because of their radiolucency, ability to be used in uncontained metastatic lesions of bone, and ability to create curvilinear constructs capable of recreating the entirety of the periacetabular columns. Furthermore, previous research demonstrated that the use of PDNs resulted in shorter operative time, less blood loss, and improved physical function compared to open surgery[9]. The purpose of the current retrospective, bi-institutional feasibility study was to describe the impact of this surgical technique among 39 consecutive patients with symptomatic metastatic bone disease of the pelvis in terms of pain relief, restoration of function and ambulation, and reduction in postoperative opioid analgesia. We hypothesized that the use of percutaneous PDNs would result in decreased pain, improved functional outcomes and level of ambulation, and decreased use of opioid pain medication.

Materials and Methods

Study Design and Setting

Institutional review board approval was obtained prior to the beginning of the study. A retrospective chart review of the electronic medical records of patients treated at 2 large, academic tertiary care centers was conducted.

Participants

Patients who had impending or minimally displaced pathological fractures in the periacetabular area due to metastatic bone disease and who underwent stabilization with PDNs (IlluminOss Medical) were included. Indications for surgery were severe pain on ambulation or even with immobilization, impaired mobility, and/or radiographic evidence of compromise of the pelvic structural integrity. Exclusion criteria included gross pelvic discontinuity, fracture displacement of >5 mm, and nonmalignant etiologies such as osteoradionecrosis.

Procedures were classified as simple or complex depending on the complexity of the operation. Simple procedures involved stabilization of only 1 periacetabular area with 1 or 2 PDNs (Fig. 1-A). To be classified as a complex intervention, procedures required 3 PDNs, reinforcement of >1 anatomic area, or use of additional hardware (e.g., THA components, an intramedullary nail [IMN]) (Fig. 1-B). Complex procedures were performed when there was extensive metastatic involvement of the pelvis, particularly the acetabular area, and/or femur that required a more extensive operation. All procedures, both simple and complex, were performed in a single-stage fashion. Because of the novelty of this surgical technique, all cases were performed between 2020 and 2022.

Variables and Outcomes of Interest

The following demographic and clinical parameters were obtained from each patient's chart: age, sex, body mass index (BMI), type of primary tumor, American Society of Anesthesiologists (ASA) class, age-adjusted Charlson Comorbidity Index (CCI), Eastern Cooperative Oncology group (ECOG) Performance Status, type of surgery (simple or complex), and follow-up duration (in months).

Surgical parameters retrieved were the following: operative time (in minutes), estimated blood loss (in mL),

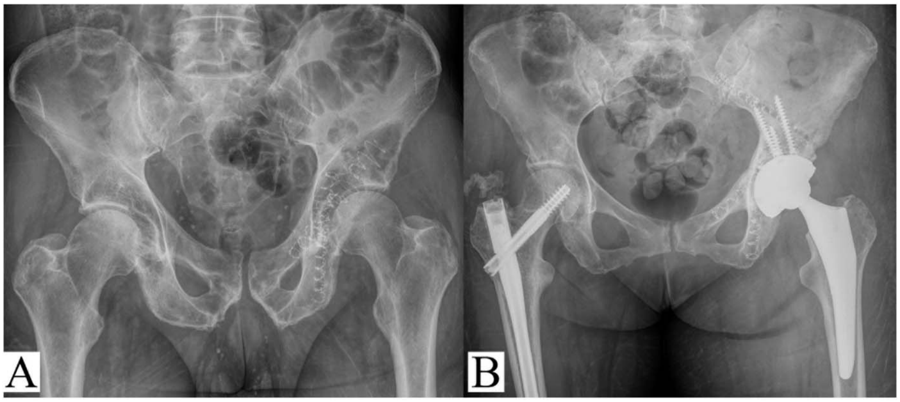

Fig. 1

Postoperative radiographs of a patient who underwent a simple photodynamic nail (PDN) stabilization procedure (**Fig. 1-A**) and a complex PDN stabilization procedure with additional total hip arthroplasty (**Fig. 1-B**).

need for intraoperative or postoperative blood transfusion, intensive care unit (ICU) admission, postoperative complications, including implant failure and surgical site infection, and 90-day mortality. In the case of complex procedures, operative time included both PDN stabilization and placement of additional hardware such as THA components or an IMN.

The primary outcomes of interest were postoperative functional outcomes, pain as assessed using a visual analog scale (VAS), level of ambulation, and use of opioid analgesia. Secondary outcomes were the ICU admission rate, postoperative complications, including implant failure and surgical site infection, and 90-day mortality. The VAS was reported by patients, ranging from 0 (no pain) to 10 (maximal pain). Functional outcomes were assessed using both physician- and patient-reported outcome (PRO) scores. The ECOG Performance Status Scale was the only physician-based tool employed. ECOG scores range from 0 to 4, with 0 denoting full activity and 4 indicating complete disability. PROs were assessed using the Combined Pain and Ambulatory Function (CPAF) questionnaire and the Patient-Reported Outcomes Measurement Information System (PROMIS). We used 2 PROMIS-derived questionnaires: the PROMIS Physical Function-Short Form 10A (PROMIS Physical Function) and PROMIS Global Health Short Form-Physical (PROMIS Global Health-Physical). All primary outcomes were assessed longitudinally at the preoperative, 6-week, 3-month, 6-month, and 1-year marks. Clinical outcomes, PROs, and physician-based scores were assessed for all patients preoperatively, 36 patients at the 6-week mark, 17 patients at the 3-month mark, 16 patients at the 6-month mark, and 5 patients at the 1-year mark. Data on opioid use and weight-bearing status were limited to a smaller subset of patients at specific time points. Opioid use at 3 months, 6 months, and 1 year postoperatively could be assessed in 11, 15, and 4 patients, respectively. Weight-bearing status could be evaluated in 15 patients at the 3-month and 6-month marks and 4 patients at the 1-year mark.

Operative Technique

All surgical interventions were performed because of symptomatic metastatic disease of the pelvis (Fig. 2). The

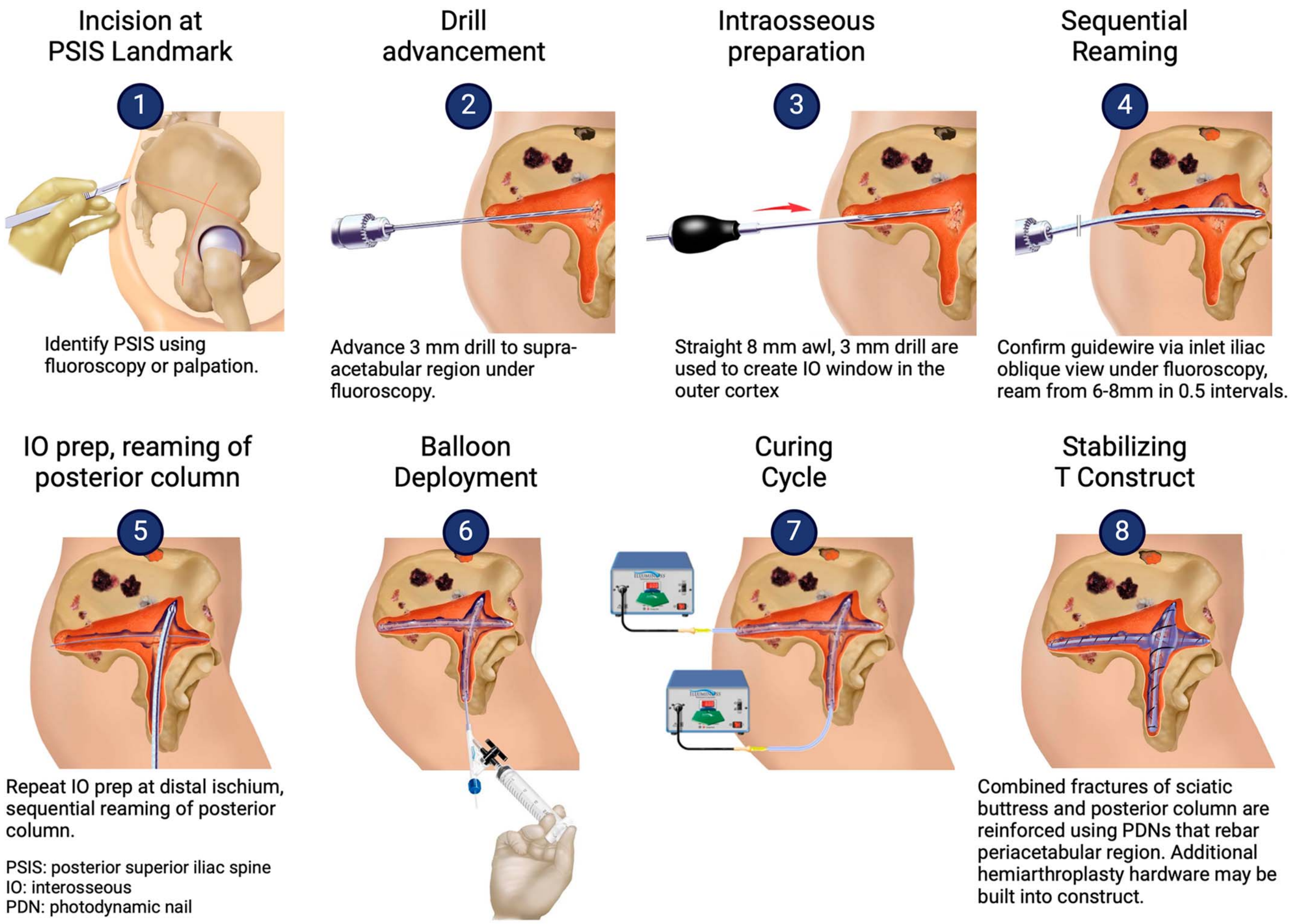

Fig. 2

Surgical approach for the stabilization of metastatic pelvic lesions.

TABLE I Demographic Summary of the Operative Cohort (N = 39)*

Age† *(yr)*	68 (60-74)
Female sex	21 (54%)
BMI† *(kg/m²)*	25.8 (21.7-29.2)
Age-adjusted CCI†	10 (8-10)
Tumor histology	
Multiple myeloma	10 (26%)
Lung	8 (21%)
Breast	7 (18%)
Other	9 (23%)
Prostate	5 (13%)
ASA class	
2	3 (8%)
3	34 (87%)
4	2 (5%)
Type of surgery	
Simple	24 (62%)
Complex	15 (38%)
Follow-up† *(mo)*	6.1 (1.9-26.4)

*The values are given as the number, with the percentage in parentheses, except where otherwise noted. BMI = body mass index, CCI = Charlson Comorbidity Index, and ASA = American Society of Anesthesiologists. †The values are given as the median, with the interquartile ranges in parentheses.

procedure rebars the periacetabular area of the pelvis through reinforcement of the posterior column, the sciatic corridor, and the supra-acetabular area, using photodynamic balloons. Stabilization of the posterior column is typically performed with a balloon inserted up the ischium while the sciatic corridor is stabilized with a balloon advanced from the posterior inferior iliac spine to the anterior inferior iliac spine. Stabilization of the anterior column may be done in a retrograde manner from the ipsilateral superior pubic ramus of the patient's affected hip if additional stabilization is necessary in the supra-acetabular area or over the root of the superior pubic ramus. The anterior column can also be fixed in an antegrade fashion from the lateral supra-acetabular area to the superior ramus. Multiple balloons can be placed. The procedure can be performed with the patient in the supine or prone position (with our preference being the prone position), on a radiolucent table and with chest rolls to facilitate hip flexion. Our surgical technique and preference were previously described[9]. Even though the procedure can be performed only with fluoroscopy, it is highly recommended that this surgery be performed under computed tomography (CT)-guided computer navigation in addition to fluoroscopy, given the bone destruction and the lack of tactile feedback while drilling through the affected osseous structures of the pelvis. After curing, the balloons create a rotationally stable implant between the inner and outer cortex of the hemipelvis.

Statistical Analysis

Demographic, clinical, and treatment characteristics are reported using descriptive statistics. The normality of the distribution of data was assessed using the Shapiro-Wilk test. Because of non-normal distributions, we report the median and interquartile range for continuous variables. Differences between groups were assessed using the chi-square test for categorical variables. A comparison of continuous variables at different time points was performed using the Kruskal-Wallis test. A post-hoc nonparametric comparison of subgroups was conducted using the Dunn test. A p value of <0.05 was considered significant. All statistical analyses were conducted using Stata (StataCorp).

Results

A total of 39 patients treated with PDNs were ultimately included in our analysis. The median age was 68 years, the median BMI was 25.8 kg/m², and multiple myeloma was the most common type of primary tumor (Table I). The median follow-up was 6.1 months, and 38% of the patients underwent a complex procedure. Overall survival at 3 months, 6 months, and 1 year was 89%, 71%, and 67%, respectively (Fig. 3). The median time to start/resume chemotherapy and radiation therapy was 26 and 23 days, respectively. Neoadjuvant radiation therapy was administered in 5% (2) of the 39 patients, while adjuvant radiation therapy was administered in 39% (15) of the 39 patients.

The median operative time for the entire cohort was 160.5 minutes (Table II). Complex procedures took significantly longer (273 versus 113 minutes; $p < 0.001$) and had a higher median estimated blood loss (300 versus 75 mL; $p = 0.015$) than did simple procedures. Intra- and/or postoperative blood transfusions were required in 13% and 60% of patients undergoing simple and complex PDN stabilization, respectively ($p = 0.002$).

Postoperative Complications

Throughout the observation period, there were no superficial or deep surgical site infections (Table II). Postoperative

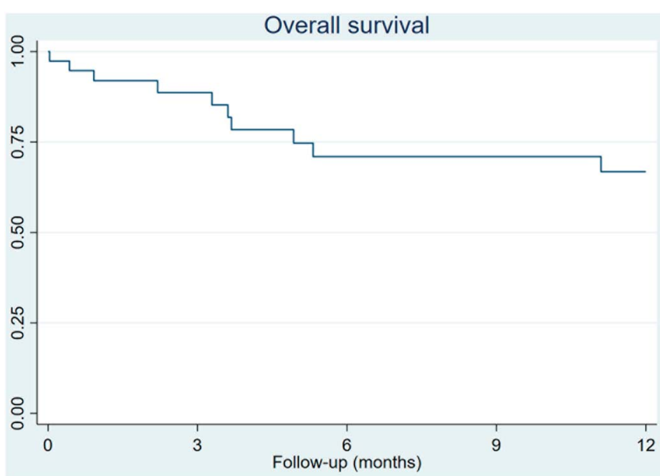

Fig. 3
Overall survival of patients.

TABLE II Perioperative Course According to the Type of Surgery*

	All Patients (N = 39)	Simple (N = 24)	Complex (N = 15)	P Value
Operative time† *(min)*	160.5 (112-261)	113 (92-159)	273 (196-431)	<0.001
EBL† *(mL)*	150 (30-400)	75 (27.5-175)	300 (100-900)	0.015
Blood transfusion	12 (31%)	3 (13%)	9 (60%)	0.002
ICU admission	2 (5%)	0 (0%)	2 (13%)	0.066
Postoperative complication(s)	8 (21%)	4 (17%)	4 (27%)	0.45
Implant failure	0 (0%)	0 (0%)	0 (0%)	
Surgical site infection	0 (0%)	0 (0%)	0 (0%)	
Mortality within 90 days	4 (10%)	2 (8%)	2 (13%)	0.62

*The values are given as the number, with the percentage in parentheses, except where otherwise noted. EBL = estimated blood loss, and ICU = intensive care unit. †The values are given as the median, with the interquartile range in parentheses.

complications occurred in 21% of the patients undergoing PDN stabilization. Two patients required postoperative closure due to noninfectious wound dehiscence that resolved immediately following surgical treatment. Additionally, 2 patients undergoing complex THA-PDN required revision surgery at 7 and 14 months due to aseptic loosening of the arthroplasty implant. Three patients exhibited deep venous thrombosis within 3 weeks of their procedure. One patient developed hypotension in the early post-operative period due to underlying cardiac disease. Because of reasons unrelated to the PDNs, 2 patients were admitted to the ICU. Ten percent of patients died within 90 days of their operation; none of them died as a result of failure of the PDN or postoperative complications related to the implant.

ECOG Performance Status

Preoperatively, 89.3% of patients had ECOG scores between 1 and 3, and <4% were designated as ECOG 0 (Fig. 4). While the frequency of ECOG 1 was relatively unchanged throughout the postoperative period, the distribution of ECOG 0 steadily increased from 3.6% to 60% through 1 year of follow-up.

Functional Outcomes and Postoperative Pain

The median pain VAS score decreased from 8 preoperatively to 0 at the 6-week mark ($p < 0.0001$) (Fig. 5-A). Lower pain VAS scores compared with preoperative values were seen at all additional time points ($p < 0.001$). The median CPAF score improved from 5.5 points preoperatively to 7 points at the 3-month mark ($p = 0.0132$) (Fig. 5-B). CPAF scores continued to

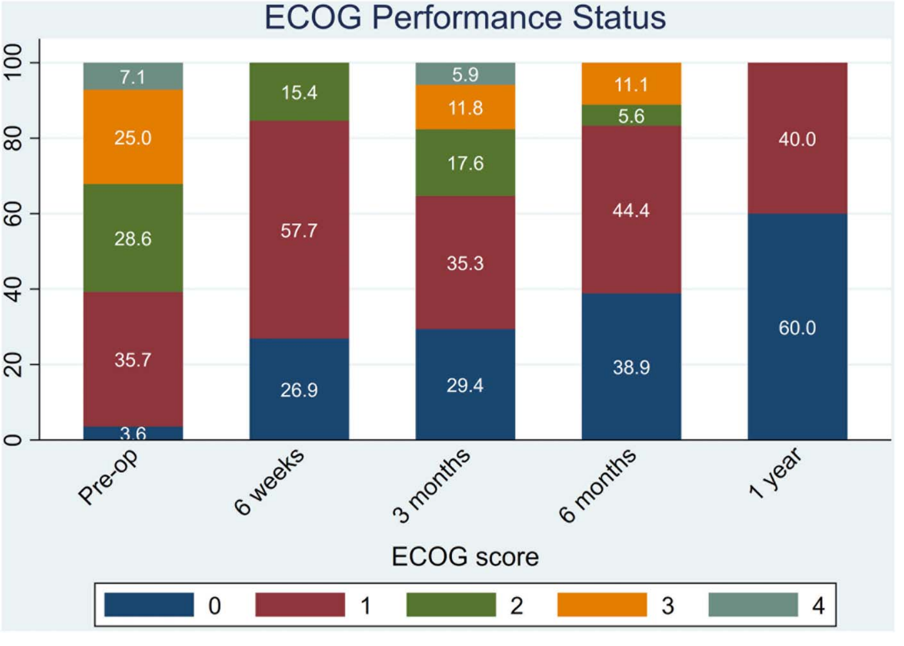

Fig. 4

Distribution of patient scores on the Eastern Cooperative Oncology Group (ECOG) Performance Status Scale at different time points.

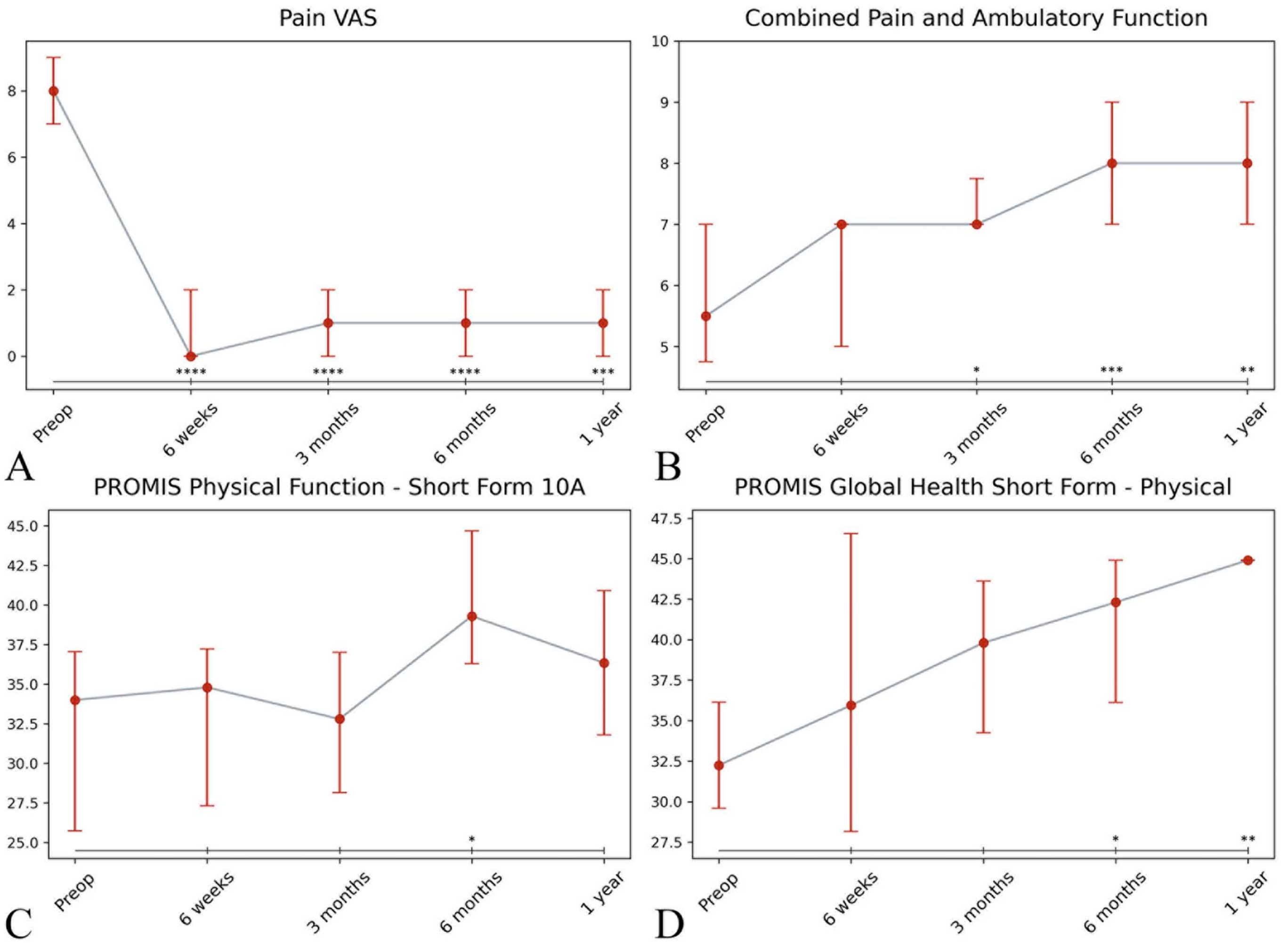

Fig. 5

Pain and functional outcomes as assessed using the visual analog scale (VAS) for pain (**Fig. 5-A**), Combined Pain and Ambulatory Function (**Fig. 5-B**), Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (**Fig. 5-C**), and PROMIS Global Health-Physical (**Fig. 5-D**). Values shown refer to the median and interquartile range (bars). Significance compared to preoperative assessment is highlighted above each data point with relevant asterisks: *p < 0.05, **p < 0.01, ***p < 0.001, and ****p < 0.0001.

increase and were higher compared with preoperatively at the 6-month ($p < 0.001$) and 1-year ($p = 0.001$) marks. A significant improvement in physical function was seen at 6 months as assessed by the PROMIS Physical Function ($p = 0.02$) (Fig. 5-C) and at both 6 months ($p = 0.01$) and 1 year ($p < 0.01$) for the PROMIS Global Health-Physical (Fig. 5-D).

We compared outcomes between patients treated with simple versus complex procedures. Both groups experienced notable pain relief and steady improvement in CPAF scores. Differences between the groups were seen at the 3-month mark for the pain VAS (Fig. 6-A), and at the 3-month and 1-year marks for the CPAF (Fig. 6-B). A trend toward better PROMIS Physical Function (Fig. 6-C) and PROMIS Global Health-Physical (Fig. 6-D) scores in patients who underwent simple compared with complex procedures was seen. Only the 6-month PROMIS Physical Function scores differed significantly between the groups ($p = 0.01$).

Prior to surgery, all patients required opioids for pain management. The rate of patients using opioid drugs for pain management diminished to 47.4%, 27.3%, and 20% at the 6-week, 3-month, and 6-month marks, respectively ($p < 0.001$ for preoperatively versus 6 months) (Fig. 7). Although the rate increased to 50% at the 1-year follow-up, only 4 patients were evaluated for opioid usage at that time point. An additional subanalysis revealed no differences in the pain VAS and opioid use between male and female patients at any of the assessed time points ($p = 0.20$ to 0.99).

Postoperative Patient Ambulation

Nearly 70% of patients had non-weight-bearing (NWB) status prior to surgery, with all remaining patients having the status of full weight-bearing (FWB) with assistive devices (Fig. 8). At 6 weeks postoperatively, 36.4% of patients had the status of FWB without assistive devices, with all remaining having the

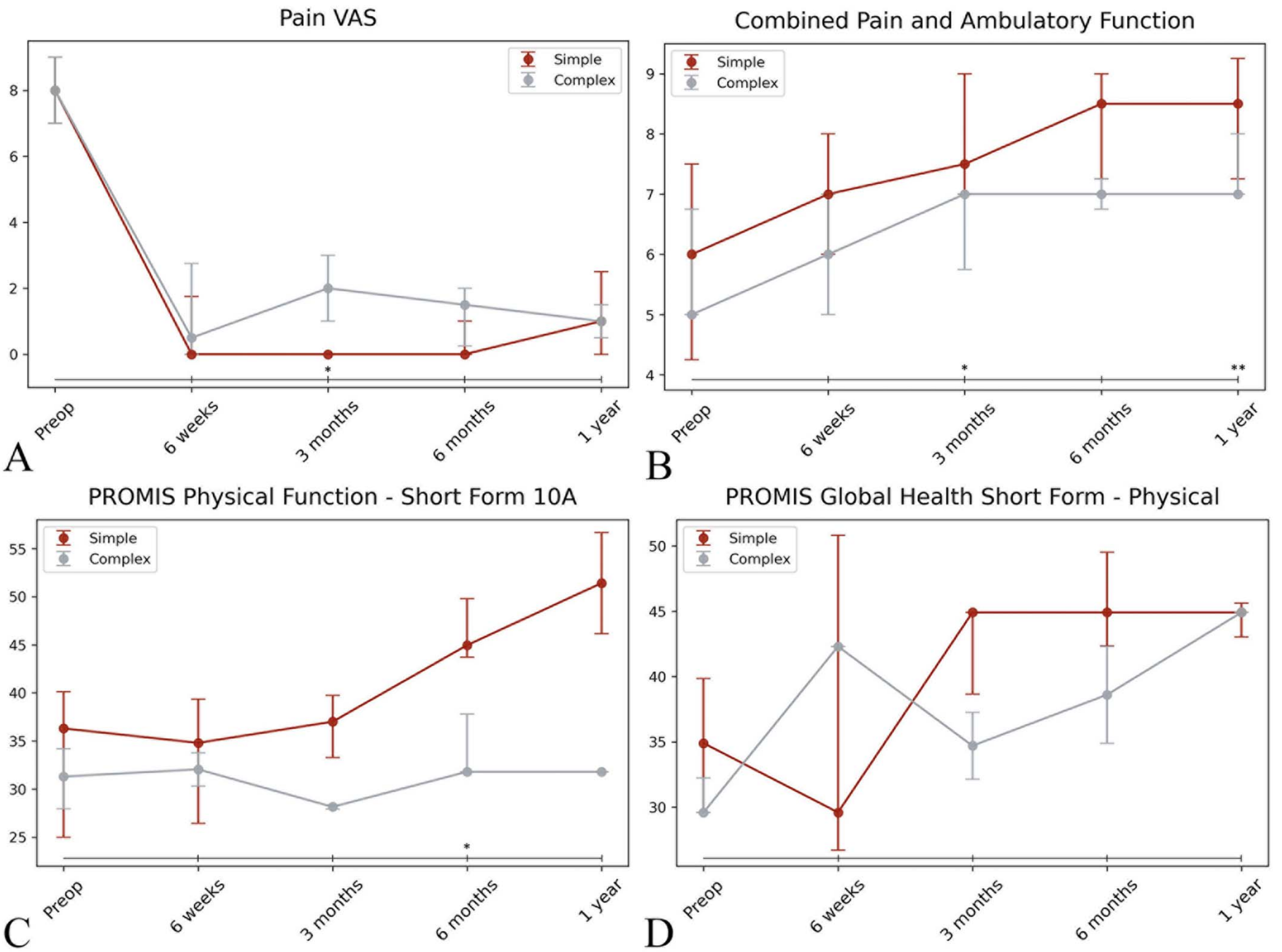

Fig. 6

Pain and functional outcomes by type of surgery (simple versus complex) as assessed using the pain visual analog scale (VAS) (**Fig. 6-A**), Combined Pain and Ambulatory Function (**Fig. 6-B**), Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (**Fig. 6-C**), and PROMIS Global Health-Physical (**Fig. 6-D**). Values shown refer to the median and interquartile range (bars). Significance (simple versus complex) is highlighted above each data point with relevant asterisks: *p < 0.05, and **p < 0.01.

status of FWB with assistive devices. At 1 year postoperatively, 75% of patients had the status of FWB without assistive devices.

Discussion

Metastases of the periacetabular and pelvic regions often cause highly debilitating pain in oncological patients that severely limits their mobility, while drastically reducing quality of life. Mainstay operative treatment for pelvic metastatic bone disease is centered around pain management, preservation of mobility, and prevention of acetabular fractures. Since weight-loading forces typically cross the superior and posterior acetabular regions during the gait cycle, preservation of the structural integrity of the posterior column and supra-acetabular region is paramount to maintaining the ability of a patient to walk, and prophylactic stabilization focuses on these areas. Surgical approaches have traditionally focused on percutaneous cementoplasty, or on open techniques such as saddle implants in non-reconstruction cases, complex THA with or without concomitant reinforcement using cementoplasty, and periacetabular smooth or threaded Schanz pin reinforcement[10]. Despite potential durable reconstructions and reassuring radiographs with these techniques, delays in resuming chemotherapy or radiation therapy are common[11], and complications rates are high[12,13].

New percutaneous and minimally invasive surgical techniques have been shown to be effective in controlling pain and restoring or improving patient ambulation at relative low risk (Table III). Yang et al. described the "tripod" technique as a means of stabilizing the periacetabular bone in metastatic bone disease[4]. In their study, all 20 patients displayed significant improvement in terms of pain and function. English et al. expanded the concept of percutaneous pelvic stabilization by combining large-bore-screws with cement[5]. In a comparative case series of 38 patients, all patients improved, as rated by the Musculoskeletal Tumor Society score, and narcotic pain medication use decreased by

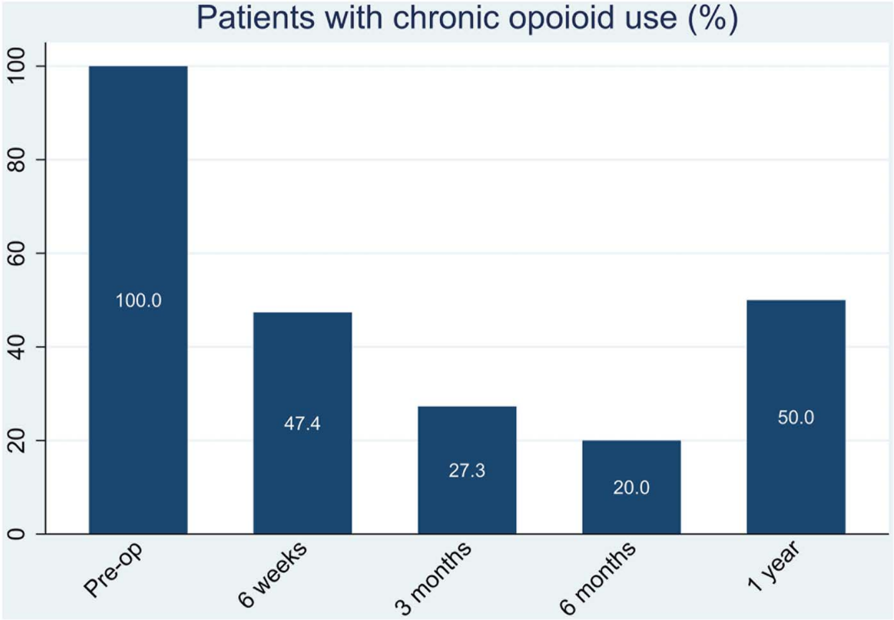

Fig. 7
Percentage of patients prescribed opioid analgesia at different time points.

82%. Houdek et al. demonstrated that porous tantalum acetabular reconstruction had fewer complications with a more robust mechanical profile when compared with the Harrington technique[8]. Lastly, Lee et al. reported on the technique of ablation, osteoplasty, reinforcement, and internal fixation (AORIF), consisting of minimally invasive image-guided ablation, osteoplasty, reinforcement, and internal fixation of symptomatic lesions of the pelvis and other periarticular areas of weight-bearing in long bones[6]. That technique was also demonstrated to be effective in pain control and improvement of function.

The primary goal of the current retrospective, bi-institutional feasibility study was to evaluate the performance of PDNs in the treatment of impending or minimally displaced pathological fractures of the pelvis secondary to metastases in skeletally mature adults. Most patients received radiation postoperatively, as the included patients in this series had large

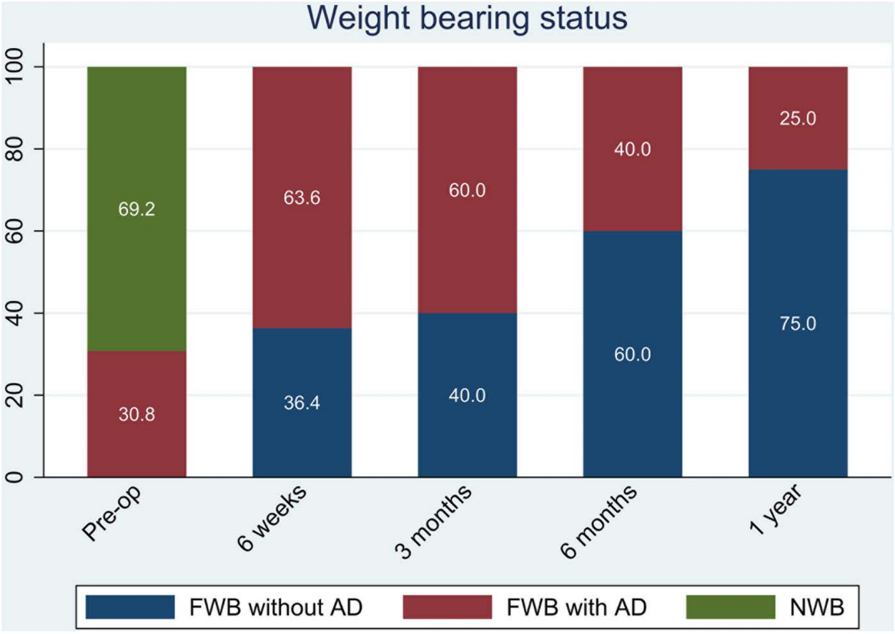

Fig. 8
Weight-bearing status at different time points. AD = assistive devices, FWB = full weight-bearing, and NWB = non-weight-bearing.

TABLE III Relevant Literature in the Surgical Management of Periacetabular Lesions

Authors (Year)	Patient sample (N)	Purpose	Conclusions
English et al. (2021)[5]	38	Analysis of functional outcomes of treatment of metastatic periacetabular lesions using invasive osteoplasty and screw fixation, with or without ablation	Improved restoration of functionality and pain relief compared with open techniques; minimally invasive technique did not delay chemotherapy or radiation therapy access
Houdek et al. (2020)[8]	115 (78 Harrington; 37 tantalum)	Analysis of clinical outcomes of the Harrington technique versus tantalum acetabular component reconstruction for periacetabular metastases	Patients with tantalum reconstruction had fewer complications with a hardier construct
Lee et al. (2020)[6]	26	Assessment of outcomes and complications with an alternative open surgical technique for osteolytic defects in periarticular regions	AORIF is a safe surgical technique for the management of osteolytic invasion of the pelvic girdle and periacetabular region
Yang et al. (2020)[4]	20	Treatment of metastatic periacetabular lesions with fluoroscopy-guided placement of a “tripod” of cannulated percutaneous screws	Safe and effective pain relief by 3 mo, decreased % of opioid usage

lesions at risk for fracture that could have completed or progressed if radiation therapy had been delivered before prophylactic stabilization. Therefore, our preference is to approach lesions in the pelvis following the same principles as management of metastatic disease in the extremities. Large lesions at high risk for fracture in the periacetabular area (subtrochanteric equivalent) should be fixed before receiving treatment with radiation. Smaller lesions without, or with very low, risk of fracture should be treated with radiation therapy or other available ablation techniques, such as radiofrequency ablation or cryoablation. In agreement with our hypothesis, we demonstrated that the technique employing PDNs resulted in clinical and significant improvement in pain and functionality. Despite the palliative nature of the procedure, oncologic metrics of function such as the ECOG Performance Scale indicated a dramatic increase in the percentage of fully active patients at the 1-year follow-up mark[14]. By 6 weeks, we found that all patients assessed were fully weight-bearing, with or without assistive devices, with minimal pain, which was a radical improvement from the cohort’s preoperative mobility status.

Moreover, narcotic usage, surgical site infection, ICU admission, weight-bearing status, and 90-day mortality rates were studied to provide a summary of perioperative outcomes. The chronic opioid usage rate dropped by 80% from preoperatively to 6 months postoperatively. Furthermore, controlling intractable cancer pain could be crucial in optimizing patient survival and minimizing the risk of opioid-associated deaths in cancer survivors[15,16].

Complication rates were minimal, as described above, with no incidence of implant failure or surgical site infection, and ICU admission was limited to 5% of the cohort. Although 4 patients had died within 90 days of the procedure, there were no surgery-related deaths. More importantly, there was no delay in accessing chemotherapy or radiation therapy. This further suggests that percutaneous stabilization using PDNs should be considered as a stabilizing procedure for individuals who may require additional surgical or medical interventions[5].

Compared with other surgical modalities, the greatest advantage of a photodynamic stabilization system, unlike with screws, is the customizable aspect in situ—each implant can be tailored to a patient’s personal anatomy[17]. In addition, the cured polymer is radiolucent and permits artifact-free intraoperative and perioperative visualization[9]. The length that can be achieved with these implants is substantially longer than that with screws, allowing for protection of the entire posterior column, anterior column, sciatic corridor, and sacroiliac region. PDNs have a larger diameter than screws, capable of expanding to nearly 3 times more than conventional 7.3-mm large-bore pelvic screws. This theoretically permits improved tolerance of axial forces. Unlike with uncontained cement, there is no interface between the device for fixation and the filler. There is no potential risk of migration or loosening, given the tridimensional stability, as the device conforms to the intramedullary space. There is also no extravasation in uncontained lesions or defects, given the nature of the device. For large defects that surpass the diameter of a 22-mm-diameter balloon, one can add a second balloon and deploy them simultaneously. Surgeons can therefore modify the amount of polymer, filling rate, and filling pattern to confirm excellent filling of the defect before curing the polymer. Lastly, when compared with cement, the polymer is easier to drill if additional hardware (such as screws) is needed, as in THA. The drilling does not affect the integrity of the PDN, and the pullout strength of inserted nonlocking screws is comparable with that of locking screws[18]. The potential increased blood loss compared with other minimally invasive techniques that do not use reaming is mitigated by the tamponade effect inside the metastatic lesions and in the path for the PDN once the polymer is injected into the balloon and cured, filling the entirety of the defect. In our experience, the combined use of navigation and fluoroscopy has helped to decrease operative time, which translates to less blood loss than with other minimally invasive techniques. Additional measures. such as preoperative embolization and the use of tranexamic acid, can help to further mitigate blood loss. Finally, the surgeons involved in the cases experienced a learning curve when performing the procedure. A subanalysis comparing simple procedures performed in patients in the first half of the cohort revealed a median operative time of 158 minutes compared with 103 minutes in the second half.

Limitations

Our study had several limitations. First, because of the retrospective nature of the study, no cause-effect conclusions can be drawn, only associations. Second, despite being a bi-institutional study, our sample size was limited (n = 39) and the follow-up was relatively short. The small number of patients with available data at the 1-year mark may explain the notable increase in chronic opioid use at this mark. Therefore, we recommend that physicians exert caution when interpreting the mid- to long-term results we report. We consider that this does not compromise the quality of our study but rather reflects the dire prognosis of patients with pelvic metastatic disease. Third, we did not include a control group undergoing PDN for non-oncological indications. Fourth, confounders such as disease progression in other sites, such as the spine, or metastatic involvement of additional organs may have been present and could potentially have biased our results.

Conclusions

Overall, photodynamic bone stabilization proves to be a safe and reliable procedure for the management of impending or pathological fractures due to periacetabular metastases. This surgical intervention enables early mobilization and minimizes pain interference, which notably impacts patients' quality of life. This study highlights the need for further investigation into alternative methods of pelvic fracture stabilization, along with the standardization of treatment approaches. Future studies should include a non-oncological control group as well as, ideally, a longer follow-up duration in order to provide further knowledge regarding the long-term complications of these implants. While our results showcase the efficacy of this technique in relieving pain and restoring mobility, these results are based on a small cohort; moreover, a steep learning curve associated with the procedure may be present and should be considered by surgeons. ■

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