3D-Printed Glenoid Components in Complex Shoulder Arthroplasty: Early Clinical Outcomes and Complication Analysis

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Introduction

Management of severe glenoid bone loss in patients undergoing primary or revision reverse total shoulder arthroplasty (rTSA) presents significant challenges. Traditional approaches, including hemiarthroplasty and bony–increased offset–reverse shoulder arthroplasty (BIO-RSA), have demonstrated varying success rates, particularly in cases where substantial bone loss compromises initial stability. Iliac crest autografts and allografts have been used with satisfactory outcomes but are limited by donor site morbidity and the necessity for adequate bone stock. Recent advancements in 3D printing technology have enabled the development of patient-specific glenoid implants that offer customized solutions for complex anatomical deficits. These implants provide enhanced initial stability through tailored fixation strategies, including modified peg designs, additional screws, struts to accommodate severe bone loss, and proprietary on growth surface materials. Despite promising initial results, concerns regarding cost, surgical accuracy, and long-term stability remain under investigation.

Methods

This retrospective study evaluated clinical and radiologic outcomes in patients with severe glenoid bone loss who underwent primary or revision rTSA with a custom 3D-printed glenoid implant (Restor3D) performed by a single surgeon between December 2022 and July 2024. Demographics, surgical indication, implant design specifications, preoperative and postoperative patient-reported outcomes (PROs), range of motion (ROM), imaging findings (CT and radiographs), and complications were collected. Comparisons between patients with and without complications were performed using Mann-Whitney U and Fisher's exact tests.

Results

Eighteen patients (11 women and 7 men) with a median age of 69 years (IQR 67–77) and a mean follow-up time of 17 ± 8 months were included in the study. Among the cohort, five patients underwent primary surgery, while the remaining 13 were revision surgeries, with 7 cases (39%) performed as staged revisions. Fourteen patients received a CT scan at an average of 6.8 months postoperatively (range: 3–13 months. Complications occurred in 27.8% of patients, including broken inferior or posterior screws (n=2) and implant failures (n=3). The three patients who experienced implant failures required explantation and revision surgery at a mean of 21.7 months from the index procedure. Patients with complications reported significantly higher postoperative pain (p=0.001) and markedly worse postoperative ASES scores (p=0.010) compared to those without complications. Specifically, the median postoperative ASES score and VAS score for patients with complications were 41 and 6, respectively, as opposed to 74 and 1 for patients without complications. Although not statistically significant, complications were observed exclusively in female patients (p=0.101) who were treated with 4.0 screws (p=0.101).

Additionally, there was a trend towards complications in patients with comorbidities, including diabetes (p=0.065), rheumatoid arthritis (p=0.172), and osteoporosis (p=0.172). Age, preoperative patient-reported outcomes (PROs), and both preoperative and postoperative ranges of motion (ROM) were comparable between patients with and without complications.

Discussion

Custom 3D-printed glenoid implants demonstrate potential for addressing severe glenoid bone loss with patient-specific designs that enhance initial stability and accommodate complex anatomical deficits. The data suggest that larger screws may reduce complication rates and improve implant stability compared to 4.0 screws, although statistical significance was not reached. Future studies with larger cohorts are necessary to validate these findings and optimize fixation strategies. Innovations in surgical planning and implant design may further improve outcomes and reduce failure rates associated with custom glenoid components. The high failure and complication rate in this cohort necessitates further monitoring and investigation.