# The Humeral Bone Loss (HUMBL) classification identifies patterns of bone loss that are associated with higher rates of revision, instability, and humeral loosening in primary and revision shoulder arthroplasty

Micah Jon Nieboer, Humberto Cardona, Amanda S Vazquez-Lloret, Alexander Macfarlane, Ankur Shah Narain, Jonathan D Barlow, Caroline M Chebli, John William Sperling, Joaquin Sanchez-Sotelo, Mark A Frankle

INTRODUCTION: Humeral bone loss is commonly encountered in primary and revision shoulder arthroplasty and failure to recognize bone loss preoperatively can lead to complications including humeral loosening or instability. The Humeral Bone Loss (HUMBL) classification categorizes bone loss into 5 major patterns of increasing severity: 1) Intact bone (including prior implants/hardware or abnormal bone quality) 2) isolated greater tuberosity loss or compromise (including acute fracture, nonunion and malunion) 3) segmental bone loss (defined as bone loss distal to the surgical neck) 4) ectatic bone loss (defined as expansion of the cortex compared to an intact proximal or distal segment) and 5) humeral discontinuity (defined as a separation of the humeral shaft from a prior implant or where a new implant would be placed). The purpose of this study was to describe patterns of bone loss in primary and revision shoulder arthroplasty and stratify outcomes based on bone loss pattern.

METHODS: This multicenter retrospective review identified shoulders with humeral bone loss undergoing primary or revision shoulder arthroplasty between 2012-2022. Shoulders with no bone loss that required a humeral revision were also included. When patients required multiple revisions, each humeral revision was included as a separate case of humeral bone loss. There were 1113 shoulders included. Patterns of bone loss were identified with preoperative radiographs according to the HUMBL classification. When patients had a combination of bone loss patterns, they were grouped with the most severe pattern present. 479 shoulders (43%) had intact bone, 120 (11%) had isolated greater tuberosity loss, 369 (33%) had segmental bone loss, 86 (8%) had ectatic bone loss and 59 (5%) had humeral discontinuity. Primary outcomes were all-cause reoperation, all-cause revision, instability, and humeral loosening. κ values were calculated for both intra- and interobserver reliability utilizing a consecutive set of 125 shoulders.

RESULTS: The all-cause reoperation rate in the cohort was 20%. Compared to bone intact shoulders (12% reoperation rate), shoulders with segmental (25%, OR 2.5, p<.001), ectatic (45%, OR 6.0, p<.001), or humeral discontinuity bone loss (31%, OR 3.2 p<.001) had significantly higher reoperation rates. The all-cause revision rate was 16%. Compared to bone intact shoulders (8% revision rate), shoulders with segmental (21%, OR 3.0, p<.001), ectatic (37%, OR 6.5, p<.001), or humeral discontinuity bone loss (25%, OR 3.7 p<.001) had significantly higher revision rates. The overall rate of post-operative instability was 11%. The rate of instability was significantly higher in shoulders with greater tuberosity (8%, OR 2.7 P=.024), segmental (15%, OR 5.9, p<.001), ectatic (34%, OR 16.9, p<.001) or humeral discontinuity bone loss (25%, OR 11.3, p<.001). The overall rate of humeral loosening was 6%. The humeral loosening rate was higher in shoulders that had segmental (9%, OR 15.6, p<.001), ectatic (22%, OR 45.0, p<.001) or humeral discontinuity bone loss (17% or 32.4, p<.001). A megaprosthesis was utilized in 56 shoulders and an allograft prosthetic composite (APC) was utilized in 69 shoulders. Megaprosthesis was most frequently used in shoulders with humeral discontinuity (9 shoulders,15%) followed by ectatic (10 shoulders, 12%) and segmental bone loss (35 shoulders, 9%). APC reconstruction was most commonly utilized in humeral discontinuity (17 shoulders, 29%), followed by ectatic (21 shoulders, 24%) and segmental bone loss (28 shoulders, 8%), There was substantial intraobserver (κ 0.74) and interobserver agreement (Round 1: κ 0.65, Round 2: κ 0.61).

DISCUSSION AND CONCLUSION: The Humeral Bone Loss (HUMBL) classification has substantial intraobserver and interobserver agreement and identifies patterns of bone loss that are associated with increased rates of reoperation, revision, instability, and humeral loosening. The presence of ectatic bone loss, not previously described in shoulder arthroplasty, led to the highest rates of reoperation, revision, instability, and humeral loosening. Further research is necessary to determine the optimal treatment for each pattern of bone loss.