Utilising Virtual Population-based Anatomic Design Methods in Design of a Glenoid Component in a Reverse Shoulder Arthroplasty System

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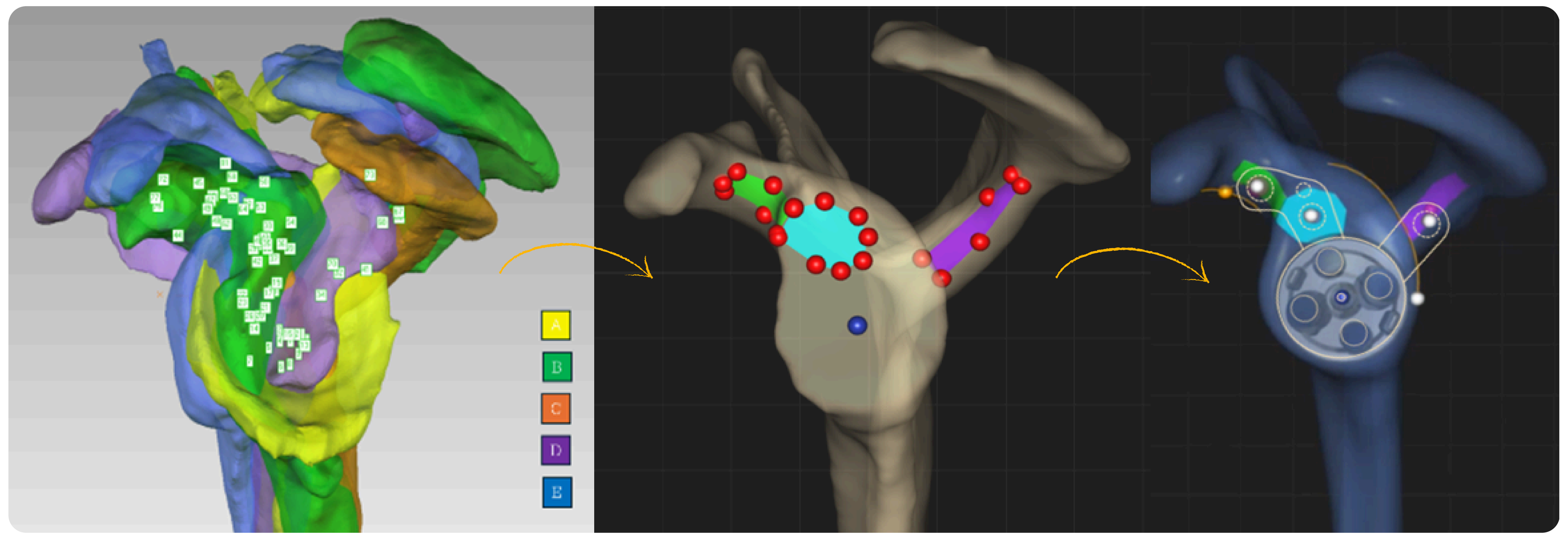
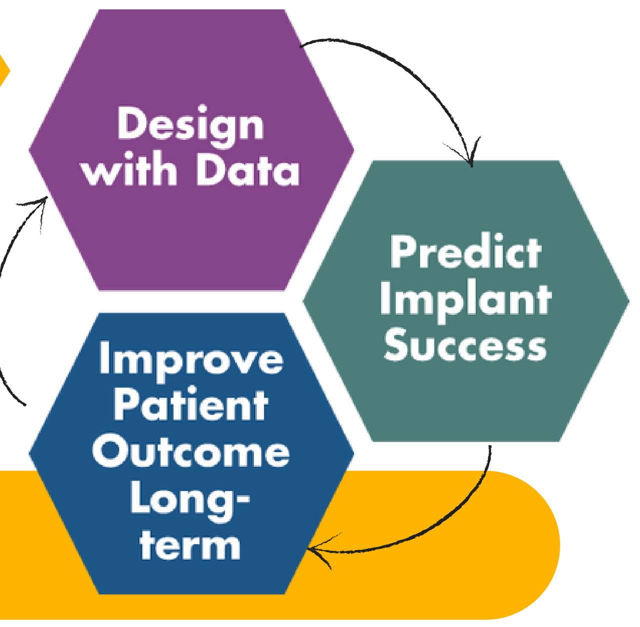


Goal

Investigate the **design, positioning, and fixation** of customized glenoid components in Reverse Shoulder Arthroplasty (RSA) using **virtual population-based anatomic design** to address challenges in **optimal fit, functionality, and patient-specific geometry.**

Purpose



Introduction

- Glenoid implants for Reverse Shoulder Arthroplasty aim to restore function among patients with various bone and soft tissue deformities, each with ranging complexity.
- Therefore, studies note the difficulty in meeting design requirements for these implants, due to anatomical variability and the heterogeneity of implant position and fit required.
- This study utilised virtual population-based anatomical design to assess ranges of deformed glenoid bones and generate a method of designing semi-customized implants using patient data and surgical planning tools, aiming to streamline design complexity.

Keywords

Surgical Planning Software, Glenoid Component, Implant Design, Virtual Population-based Design, Reverse Shoulder Arthroplasty, Anatomical Data, Semi-Custom Implants.

Literature Review Key Points

1 **Customised Medicine**
Global advancements in technology is driving demand for customized care, which provide patient specific, first-time fit solutions with improved outcomes.

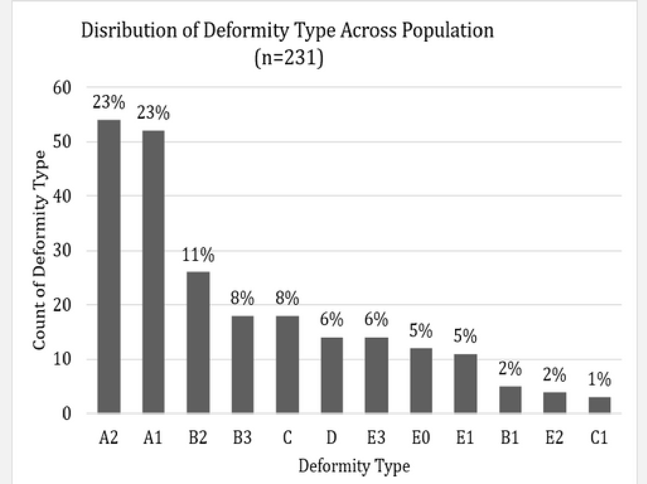
2 **Innovation in Design**
Surgical Planning software and virtual population-based design are being used to explore novel design methods, and provide care for patients who are unsuitable for traditional surgical approaches.

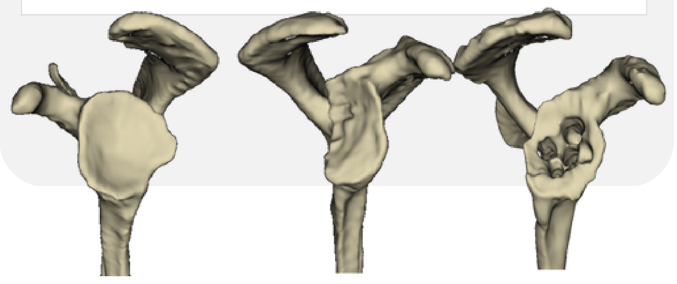
3 **Design via Data**
Databases of patient anatomical scans are enhancing surgical planning software and implant design capabilities. This enables further customization of implants and virtual implant fit and position assessments, generating data efficiently & cost-effectively.

Research Questions

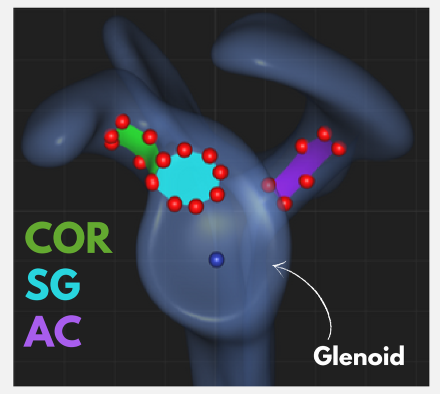
What differences exist in RSA Patient Anatomy & Deformities?

Walch and Farvard Glenoid Classification was carried out to show the population deformities. The largest deformity group was Walch Classification, A2, followed by A1, and B2, which was representative of incidence rates in RSA procedures.





Can Implant Positions and Fixation Approaches be determined?



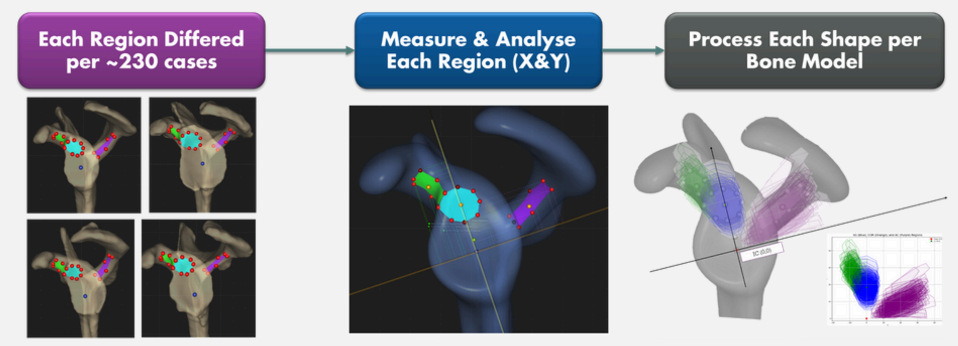
Mapping fixation points informed position on the virtual bone population.

Three key areas were determined for fixation of screws:

- Superior Glenoid (SG)
- Acromion (AC)
- Coracoid (COR)

The implant centre was determined from RSA Planning Data.

Can the findings be applied to inform the design of a glenoid component for RSA?

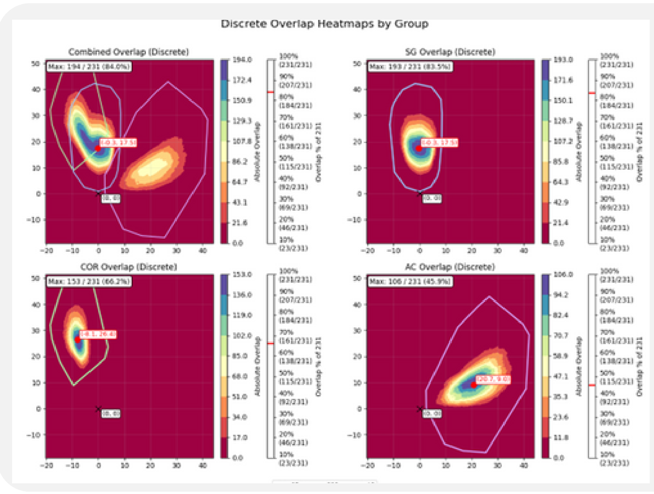


Mapping the surgical planning data points to the bone template, and then the bone model population (n=230) allowed for individual coordinate extraction across the population. The visualization of optimal coordinates and area regions for fixation targets, which would inform the glenoid implant design could then be achieved.

Methodology

A **Quantitative Methodological Approach** was utilised to design a glenoid component through population-based design approaches. An anatomical **dataset of n=230 scapula bone models** was used, with **n=25 RSA surgical plans**. Using this data, virtual population analysis software was used and Python scripts were developed, which provided results and visualized the study data.

Utilizing transformed surgical planning coordinate data, with virtual bone model populations, an analysis of position & fixation approaches were achieved, to **inform an implant design.**



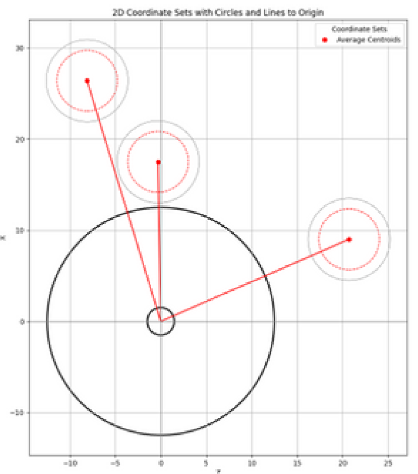
For n=230 bone models, a **Python based contour map** was created to show the area-based regions and centroidal coordinates, which determined the **optimal locations for screw fixation** across the dataset.

The centroidal coordinate in each overlap region was calculated based on the area with the greatest concentration of data points across the population.

Results

1 The **Walch classification** of the study bone models, showed Class A as the most prevalent deformity across the population (n=230), correlating with findings in literature that RSA may be associated with **complex severe central wear of the glenoid.**

2 The most common **regions for screw placement fixation** in complex bone deformity cases were the **Superior Glenoid (SG), Coracoid (COR) and Acromion (AC)**, respectively. These locations provide a secondary fixation point to the implant centre; vital for stable fixation for cases with minimal central bone density as in Class A scapula bones.

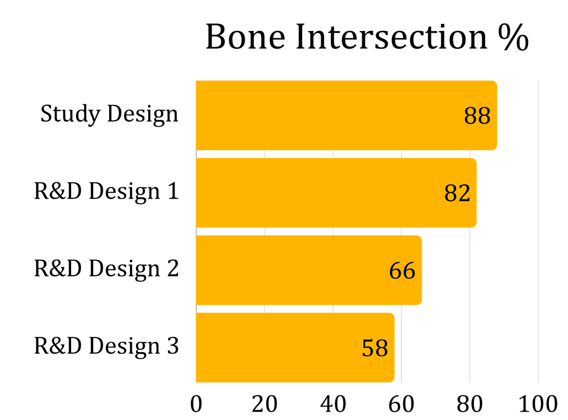


3 Utilizing the Python centroidal contour coordinate's, a proposed **implant design was generated**, which had **three fixation points** aimed to target the regions (SG, COR, AC) found as optimal fixation points for complex RSA cases.

4 The study implant design provided best results for implant fit with:

- **100%** fit of 2 screw fixation (n=230).
- **88%** fit of 3 screw fixation (n=230).

A min. of 58% and max. of 82% of all other tested traditional complex glenoid implant designs.



Key Findings

Virtual Population based methods used to **design a semi-custom implant** with **88% full screw fixation** across n=230 bone models, compared to a maximum of 82% and minimum of 58% using traditional design methods.

Virtual Population based design yielded the best fit and position results across the deformed glenoid demographic when compared to other traditional implant designs.

This method shows promise for **designing semi-custom implants** from **patient data and surgical planning**, with potential for broader applications in Orthopaedic implant design and research.

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