PREDICTING THE PREMORBID ANATOMY OF THE SCAPULA USING GENERATIVE MODELS

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Introduction

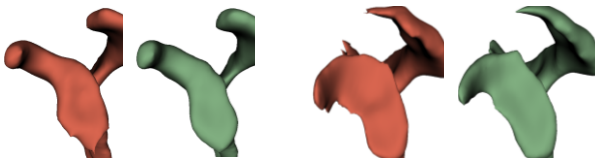
Total shoulder arthroplasty (TSA) is a surgical procedure to relieve pain and disability associated with glenohumeral osteoarthritis (OA). The goal of the procedure is to restore the anatomy and function by placing implants in the humeral head and the glenoid. The positioning of the implants plays a crucial role in the long-term success of the surgery. Due to the bone wear caused by OA, determining the proper implant position is challenging. In addition, since OA usually occurs bilaterally, preoperative planning based on the contralateral morphology is not possible. Therefore, we proposed an autoencoder-based approach to predict the premorbid scapular anatomy objectively.

Methods

Our dataset consisted of 60 healthy and 414 pathological segmented scapulae from CT scans. 12 healthy and 56 pathological cases were used for validation, and the rest were used to train our model. The model consisted of a common encoder trained with both healthy and pathological cases and two decoders that were trained separately with healthy and pathological cases. The goal of the encoder was to extract latent features from the entire dataset, and each decoder was used to reconstruct the healthy and pathological anatomy, respectively. To predict the premorbid anatomy, we used the encoder with the decoder that had been trained with healthy cases. This method allows objective prediction of the premorbid scapular anatomy based on the healthy cases in the dataset.

Results

The reconstruction accuracy of the autoencoders was found adequate, yielding a Dice overlap of 91% and 89% for healthy and pathological cases, respectively. Visual comparison of the pathological cases with their premorbid predictions showed that osteophytes present in pathological cases were reduced or completely removed in the premorbid reconstructions (Fig. 1a). In addition, biconcave glenoid cavities found in some pathological cases were corrected to a uni-concave surface after reconstruction (Fig. 1b). Finally, we investigated the difference between the glenoid version, an important parameter for surgical planning, of pathological cases and their premorbid prediction. Glenoid version of pathological cases was more posterior than healthy ones, with an average difference of 5.4°. However, the same comparison between pathological cases and their premorbid predictions revealed an average correction of only 1.9° (Fig. 2). Although the statistical analysis showed that there is a significant difference between the glenoid version of the pathological cases and their premorbid predictions ($p = 0.001$), this does not correspond fully to the healthy scapulae.



(a) (b)

Figure 1: Two examples of pathological glenoid (red) and their premorbid reconstruction (green), where the pathological osteophyte formation (a) and glenoid concavity (b) has been partly corrected after reconstruction.

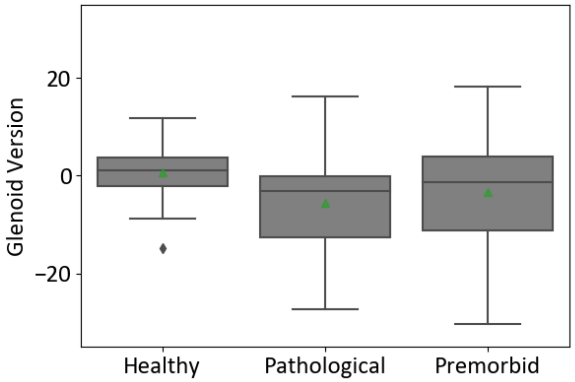


Figure 2: Glenoid version of healthy and pathological cases, with corresponding premorbid reconstructions

Discussion

In this study, we proposed an approach based on auto-encoders to predict the premorbid anatomy of the scapula. Visual inspection showed that pathologies, such as osteophytes and biconcave glenoid cavities, were corrected and represented a healthier anatomy. However, the glenoid version of the premorbid reconstructions remains lower than in healthy control subjects. In the future, we will extend this work with generative adversarial networks to enforce more realistic glenoid version in the premorbid predictions.

Acknowledgements

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