A non-invasive method to identify suitable volume and geometric pattern for harvesting the bone in autografting surgery

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Summary

Bone grafting is a common orthopedic procedure used to transplant bone tissue from the donor site to the defective bone site of the patient. Amongst the various anatomical sites, the iliac crest is considered as the most preferred site to harvest bone for auto-grafting because of the presence of rich cortico-cancellous bone, low morbidity and versatility. However, this procedure is associated with post-surgical complications which result in pelvic instability and chronic pain.

Introduction

Autografting involves the transfer of bone tissue to areas compromised by trauma, infection or disease-related bone loss, thereby stimulating cellular regeneration and promoting bone repair [1]. However, the selection of grafting material to perform the surgical procedures is influenced by multiple factors, including defect size, location and overall health status of the patient [2]. Although bone for autografting typically involves harvesting from the pelvis, the iliac crest is most preferred due to presence of rich cortico-cancellous bone [3]. The unplanned surgical procedures can compromise the mechanical integrity of the pelvis and potentially leads to fracture, fragility, instability and altered biomechanics. Therefore, rigorous attention is essential to mitigate these risks and ensure successful outcomes.

Methods

In this study, a non-invasive finite element analysis was performed to identify the feasible regions to harvest the bone for auto-grafting. As a procedure the CT data set of a 35-years-old male was considered for the 3D modelling of pelvis. Three different regions of pelvis namely iliac crest, ilium and sacroiliac joint were considered for the analysis as shown in Figure 1a. Based on pelvis anatomy, the sacroiliac joint was fixed for the analysis and a load of 600 N derived from the body weight of the patient was applied on the pelvis considering single leg-stance conditions (Figure 1b). To harvest the bone for grafting, a bone end-milling simulation was performed using Abaqus®. Then the results were compared with the conventional bone harvesting method (Figure 1c).

Results and Discussion

The von Mises stress developed in the pelvis was lesser at the iliac crest (0.96 MPa), followed by ilium (2.40 MPa) and sacroiliac joint (5.30 MPa) under normal conditions. A highest of 17.43 MPa (Figure 2a) von Mises stress was developed at the iliac crest after extracting a 20 cm^3 bone for

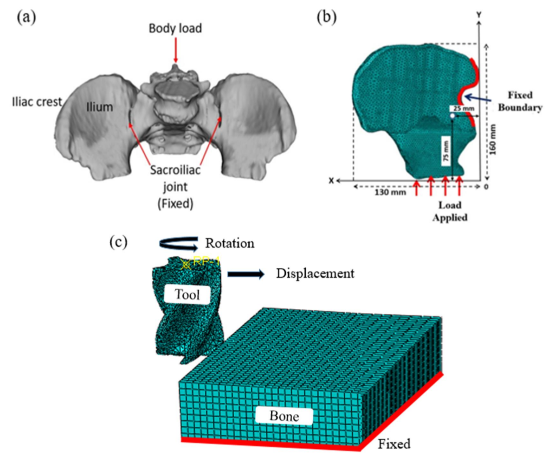

Figure 1: (a, b) 3D CAD model of the pelvis and (c) bone milling model

grafting using the rectangular window technique. It was found that using the elliptical trapdoor technique of bone harvesting, a maximum of 18.35 cm^3 volume of cortico-cancellous bone could be harvested from the iliac crest without exceeding critical stress, which was 7.95% higher compared with the rectangular trapdoor technique.

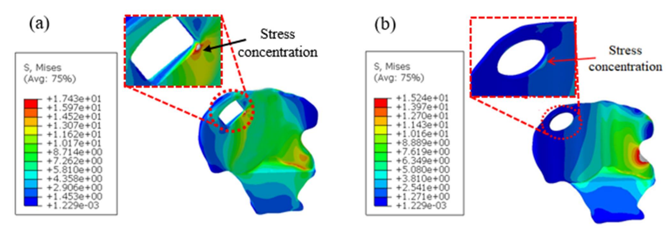

Figure 2: Stress analysis bone harvesting in pelvis.

Conclusions

This study concluded that the trapdoor technique using elliptical pattern yields less von-Mises stress compared with window technique. Also, to fill a fracture void, a maximum of 18.35 cm^3 volume of cortico-cancellous bone could be harvested from iliac crest without exceeding the critical stress limit. The findings of this study provide insights to the surgeons related to harvesting site and graft volume to be extracted from pelvis to avoid any critical damage post-surgery. Also, milling can be suitably performed to reduce the mechanical damages.

References

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