Feasibility of Custom Image-based Immobilization (IBI) as a Replacement Immobilization Device without Re-simulation

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Innovation/Purpose

This study is innovative because it offers a new way for lost immobilization device replacement. In a clinical situation when the patient's mold, Alpha cradle or Vac-lok get lost, damaged or misplaced, the only solution is re-simulation. It is an infrequent and undesired event even for big institutions or cancers centers with multiple satellites, but certainly happens, especially when patients are transferred between sites and the immobilization devices are shipped regularly.

In this preliminary feasibility study, we evaluate the potential of utilizing image-based custom immobilization device as replacement without re-simulation should a posterior immobilization device made during simulation is misplaced or becomes unusable

Methods

One volunteer subject underwent pelvic MR-only simulation with standard alpha cradle immobilization. From the initial simulation images, a custom machine-milled Styrofoam posterior mold was fabricated. The volunteer returns for the same MR simulation with the custom image-based immobilization (IBI) device and the original alpha cradle for setup alignment comparison. Rigid registration with bony alignment was performed and the mutual information, root mean square difference and rotations were calculated. The external body contour of all three scans were created and the Dice similarity coefficient, Hausdorff distance (HD), mean distance to agreement (MDA), and Jaccard similarity index were used to perform pairwise comparisons between the external body contours from all three scans.

Conclusion

Custom image-based immobilization is an excellent alternative if the initially created immobilization device created during simulation is misplaced. The fabrication and use of such devices can eliminate the need to re-simulate and potentially re-plan. Further evaluation with more patient/volunteer subjects is needed before full clinical implementation.

Results

Evaluation of the rigid registration from the IBI scan and the alpha cradle scan to the initial alpha cradle scan showed that scanning with IBI resulted in superior mutual information, root mean square difference, and smaller rotation angles. The external contour comparison between the initial alpha cradle scan to the IBI scan achieve Dice similarity of 0.98, Jaccard index of 0.96, HD of 12.15 mm, and MDA of 2.18 mm. All metrics are comparable to the pairwise comparison between the external contour of the new alpha cradle scan and the initial alpha cradle scan. Detail metrices are shown in Table 1 and Table 2.

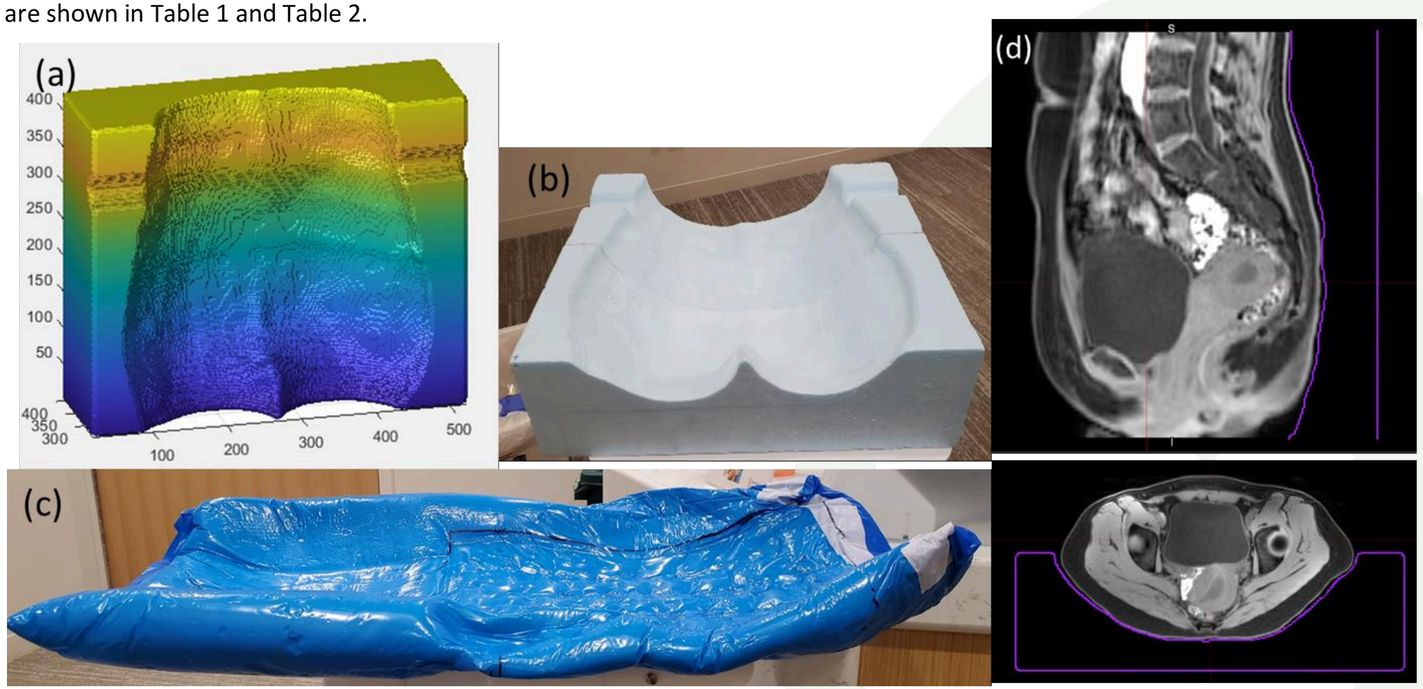

Figure 1: (a) stl surface for custom image-based immobilization device fabrication. (b) custom image-based immobilization device (c) volunteer alpha cradle (d) immobilization device contour with MR image

Contour 1	Contour 2	HD (mm)	MDA (mm)	Dice	Jaccard
InitialAlphaCradle	IBI	13.99	1.96	0.98	0.96
InitialAlphaCradle	NewAlphaCradle	12.15	2.18	0.98	0.95
NewAlphaCradle	IBI	10.34	1.58	0.98	0.96

Table 1: Pairwise external body contour comparison between initial simulation when alpha cradle was made (initialAlphaCradle), scan acquired with Image-based Immobilization (IBI) device, additional scan acquired with the same alpha cradle at a later date (NewAlphaCradle)

	IBI	NewAlphaCradle
Normalized Mutual Information	0.672	0.667
Root Mean Square Difference	209.928	216.354
Rotation (degrees)	(-0.62, -0.89, 0)	(-0.35, -2.24, -0.61)

Table 2: Parameters of Rigid Registration to the initial alpha cradle scan. IBI had better agreement to the initial alpha cradle scan when compared with the new alpha cradle scan.