Breast volume measurement using three-dimensional surface scan for fat grafting planning and monitoring

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Purpose: Breast Cancer is the most frequently occurring cancer in Canadian women. Up to 80% of these patients are candidates for breast-conserving surgery (partial mastectomy). During a partial mastectomy, the tumor is completely excised while preserving as much healthy tissue as possible. Unfortunately, up to about one-third of these patients who undergo breast-conserving surgery still experience severe breast deformity that requires surgical reconstruction. Fat grafting has been emerging as a safe and suitable modality in breast augmentation following breast-conserving surgery. The fat, harvested from donor areas of the same patient, is injected into the breast in several fractions, typically 100-150 cc each time. There is always a variable degree of fat reabsorption in the breast, which leads to often repeated fat grafting surgeries until the desired result is achieved. It is imperative to accurately monitor the changes in volume in order to plan and execute the optimal grafting regimen. Minimizing the number of fat grafting sessions decreases risk to the patient and burden to the healthcare system, as each session costs $5,000-$7,000. Currently, there is no low cost, widely available tool for the surgeon. We aimed to provide a system and clinical workflow to accurately compute volume changes of the breast, in a safe and convenient manner during a visit to the clinic.

Methods: Using the Artec Eva (www.artec3d.com) three-dimensional surface scanner a three-dimensional surface of the patient can be obtained in a non-contact manner (**Figure 1**). The patient will stand up-right position with the hands rested on the hips, this will allow the surface scan to be easily captured in under one minute. The surface scan is imported into 3D Slicer (www.slicer.org) where a module has been created for processing and visual rendering. To compute the breast volume the breast the must be isolated from the rest of the chest, this can be done along anatomical landmarks. The volume of the isolated breast can then be computed. To assist in planning the total graft volume, volume difference between the two breasts are computed by mirroring the healthy breast onto the reconstructed side. To monitor the retention of graft volume between implanting fractions, the volume difference between two consecutive scans of the same breast is computed and compared to the graft volume. Three-dimensional distribution of the volume differences over the breast is visualized on the computer display using semi-transparent surfaces and surface-to-surface distance maps **(Figure 2**) after two scans from different times within the treatment process are aligned. These visualizations will help inform the reconstruction surgeon about locations in the breast that have signification volume differences.

Figure 1. Mannequin being scanned by Artec Eva.

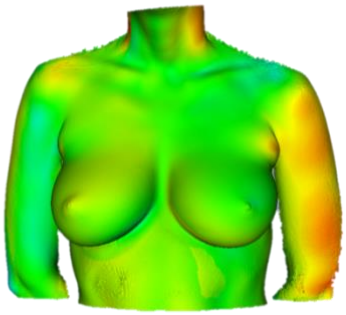

Figure 2. Surface-to-surface distance map of two scans of a volunteer after alignment.

Results: We demonstrated the ability to measure volume differences in the breast in three (3) female volunteers. Each volunteer was scanned three (3) times. Between each scan, the volunteer was asked to relax for a few seconds and reposition herself for the next scan. The breast volume of the same breast for each volunteer was computed for each of the three scans. The average difference between three consecutive measurements of the same breast was 1.1 cc **(table 1).** In addition, we also demonstrated the ability to measure the absolute volume of the breast. To this end, a mannequin's breast volume was first measured by water displacement and compared to the volume measured by our system. Having repeated each measurement five (5) times for the same breast, the average difference between the measurements was 4.1 cc. A surface-to-surface distance map (**Figure 2**) was also created for one volunteer using two of the three scans, as expected the distance map illustrated very little difference between the two scans. The small differences in the two scans can be accounted for by the volunteer not resuming the exact same scanning position and the registration error.

Table 1. Breast volume computed for three volunteers.

Volunteer	**Breast Volume (mean +/- standard deviation)**
1	341.2 +/- 0.5 cc
2	165.0 +/- 1.7 cc
3	211.4 +/- 1.2 cc

Conclusion: Considering the typical volume of a graft injection fraction (100-150cc), our accuracy in measuring breast volume changes (1.1 cc) is highly promising for clinical use. Further testing will be conducted to assess the accuracy when scanning and measuring breast volume of post partial mastectomy patients. Research Ethics Board approval has been sought to commence clinical evaluation in 25 post breast-conserving surgery patients.