JPRAS Open 35 (2023) 38–41

Contents lists available at ScienceDirect

JPRAS Open

journal homepage: www.elsevier.com/locate/jpra

Short Communication

A Novel optimization technique of Computed Tomography Angiographic 3D-reconstructions for pre-operative planning of DIEP flaps

Jevan Cevik[a,b,*], Warren Rozen[a,b]

[a] Department of Plastic and Reconstructive Surgery, Peninsula Health, Frankston, Victoria, Australia
[b] Peninsula Clinical School, Central Clinical School, Faculty of Medicine, Monash University, Frankston, Victoria, Australia

ARTICLE INFO

Article history:
Received 15 December 2022
Accepted 22 December 2022
Available online 26 December 2022

Background

Autologous breast reconstruction has become an integral part of recovery for breast cancer patients. Among the available reconstructive options, the deep inferior epigastric artery perforator (DIEP) flap, introduced by Allen and Treece in 1994, is preferred by patients and surgeons due to its resemblance to native breast tissue.[1] Yet, performing the flap is often challenging due to the variable vascular anatomy of the artery with unreliable location, size and number of its perforators.[2,3] Pre-operative imaging using computed tomography angiographic (CTA) imaging is frequently utilised to assess the vascular architecture prior to the day of surgery to improve perforator selection and reduce operative times.[3-7]

To assess the vascular anatomy of the anterior abdominal wall, radiological reporting software is utilised to generate 3-Dimensional (3D) reconstructions of the CTA scan are often constructed to give surgeons a virtual model to plan flap design.[8-10] Traditionally, when evaluating these 3D reconstructions, images would be cropped in an anterior-posterior or lateral-medial direction to bypass superficial tissues and uncover the deeper vasculature. When reporting scans in this manner, the patient's

* Corresponding author at: Department of Plastic and Reconstructive Surgery, Peninsula Health, Frankston, Victoria, Australia.
E-mail address: jevancevik@gmail.com (J. Cevik).

https://doi.org/10.1016/j.jpra.2022.12.003

Figure 1. 3D reconstruction of the patient's CTA scan utilising Horos^{TM} and volume rendering. In this image, a Guassian Blur has additionally been applied to further optimise visualisation.

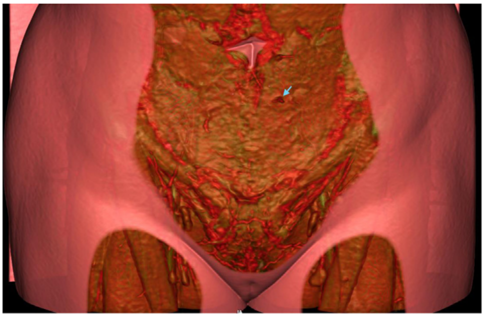

Figure 2. Traditional anterior-posterior cropped 3D reconstruction showing the removed skin of the anterior abdominal wall revealing the underlying DIEA perforators. The blue arrow represents a perforator from the left DIEA.

skin is often challenging to crop away, obscuring ideal exposure of the underlying perforators leading to poorer quality of the images produced.

In this report we introduce a simple new method to completely uncover the patient's skin and subcutaneous tissue to greatly improve the quality of images produced from CTA 3D reconstructions.

Description of technique

To report our CTA scans we utilise the software Horos^{TM} (The Horos Project, Nimble Co LLC Purview, Annapolis, MD, USA). In Horos, 3D reconstructions can be generated by utilising a volume-rendering technique (VRT). A key step when performing a VRT 3D reconstruction is the implementation of a colour look-up table (CLUT) template. This template is imperative to encode various anatomical structures with specific colours to make them visible on the 3D reconstruction in such a manner that it ensures optimal visibility of the deep inferior epigastric artery (DIEA) perforators. Additionally, the use of various filters, such as the Gaussian blur, offers even further optimisation.

At this point, the patient's entire CTA scan has been reconstructed as a 3D model. This can be seen in Figure 1. From this point, traditionally, to uncover the underlying perforators, the skin would be cropped in an anterior-posterior direction revealing the deeper vasculature (Figure 2.). In most circumstances, this offers adequate exposure of the anterior abdominal wall to visualise the perforators, however, in many cases, the restriction of 2-Dimensional cropping results in poorer quality visualisation of the perforators that would be otherwise ideal. This is particularly apparent if the surface of the patient's abdomen is not in a uniform plane, for instance, in a patient that has substantial subcutaneous fat, this will create an irregular abdominal architecture and, due to the restriction of 2D

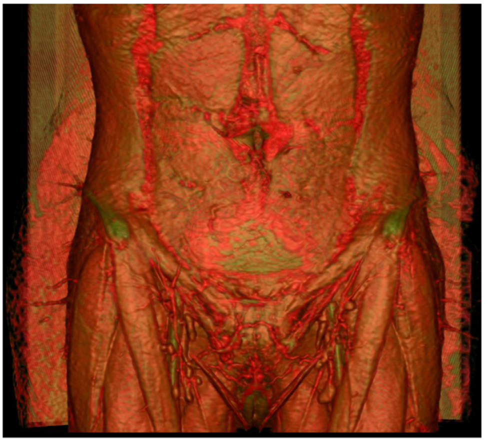

Figure 3. 3D reconstruction of the anterior abdominal wall where the skin has been removing using the CLUT editor in Horos^{TM}. The underlying musculature and vasculature is readily apparent, however, in the midline, the infraumbilical region is obscured by residual artefact that lies just deep to the overlying skin.

Figure 4. Final 3D reconstructed image of the anterior abdominal wall following removal of the artefact left behind when removing the skin. The DIEA perforators are clearly visible, the blue arrow indicators the same perforator as displayed in Figure 1. In this image, it is much easier to appreciate the exact position of this perforator relative to other structures and to get a better appreciation for the entire abdominal wall.

cropping, one is usually forced to sacrifice ideal visualisation of the perforators to ensure that adequate exposure of the abdominal wall is achieved.

To combat this challenge, we now utilise a different method to remove the patient's skin from the 3D reconstruction using the feature available in Horos^{TM} known as the colour look-up table editor (CLUT editor). The 16-bit CLUT editor will reveal the colours used in the CLUT template when performing the VRT. By utilising the 16-bit CLUT editor, one can easily remove the patient's skin by simply removing the colour assigned to it in the CLUT template, thereby making it transparent. However, this is unfortunately often insufficient to obtain optimal visualisation of the perforators as residual artefact is commonly left behind which obscures view of the underlying vasculature (Figure 3.).

To remove this artefact and perform the final step in achieving optimal visualisation of the DIEA perforators, the scissors tool is used to slice away the artefact that overlies the abdomen. This is best achieved when the 3D reconstruction is rotated and viewed in the axial plane. After this step, the final image can be obtained as shown in Figure 4.

Conclusion

In this report we describe a novel technique to remove the skin from a 3D CTA reconstruction of the abdominal wall for pre-operative planning of a DIEP flap. By effective utilisation of the CLUT editor feature and scissors tool as described herein, visualisation of the DIEA perforators, and therefore surgical planning, can be markedly improved.

Ethics

The patient whose images and videos were displayed in this article has consented to the use of these images for the purposes of this study.

Funding

No funding was obtained for this study.

Conflicts of interest

The authors declare no conflicts of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jpra.2022.12.003.

References

1. Allen RJ, Treece P. Deep inferior epigastric perforator flap for breast reconstruction. *Ann Plast Surg*. 1994;32:32–38.
2. Hembd A, Teotia SS, Zhu H, Haddock NT. Optimizing perforator selection: a multivariable analysis of predictors for fat necrosis and abdominal morbidity in DIEP flap breast reconstruction. *Plast Reconstr Surg*. 2018;142:583–592.
3. Colakoglu S, Tebockhorst S, Freedman J, et al. CT angiography prior to DIEP flap breast reconstruction: a randomized controlled trial. *J Plast Reconstr Aesthet Surg*. 2022;75:45–51.
4. Rozen WM, Ashton MW, Grinsell D, Stella DL, Phillips TJ, Taylor GI. Establishing the case for CT angiography in the preoperative imaging of abdominal wall perforators. *Microsurgery*. 2008;28:306–313.
5. Canizares O, Mayo J, Soto E, Allen RJ, Sadeghi A. Optimizing efficiency in deep inferior epigastric perforator flap breast reconstruction. *Ann Plast Surg*. 2015;75:186–192.
6. Fitzgerald O'Connor E, Rozen WM, Chowdhry M, Band B, Ramakrishnan VV, Griffiths M. Preoperative computed tomography angiography for planning DIEP flap breast reconstruction reduces operative time and overall complications. *Gland Surg*. 2016;5:93–98.
7. Haddock NT, Dumestre DO, Teotia SS. Efficiency in DIEP flap breast reconstruction: the real benefit of computed tomographic angiography imaging. *Plast Reconstr Surg*. 2020;146:719–723.
8. Rozen WM, Bhullar HK, Hunter-Smith D. How to assess a CTA of the abdomen to plan an autologous breast reconstruction. *Gland Surg*. 2019;8:S291–S2s6.
9. Clavero JA, Masia J, Larrañaga J, et al. MDCT in the preoperative planning of abdominal perforator surgery for postmastectomy breast reconstruction. *AJR Am J Roentgenol*. 2008;191:670–676.
10. Lam DL, Mitsumori LM, Neligan PC, Warren BH, Shuman WP, Dubinsky TJ. Pre-operative CT angiography and three-dimensional image post processing for deep inferior epigastric perforator flap breast reconstructive surgery. *Br J Radiol*. 2012;85:e1293–e1297.