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Role of computed tomography angiography in the diagnosis of vascular stenosis in head and neck microvascular free flap reconstruction

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Abstract. The aim of this study was to evaluate the role of computed tomography angiography (CTA) in the diagnosis of vascular stenosis at the vascular pedicle of head and neck microvascular free flaps. A prospective study was done of 65 consecutive patients (49 male, 16 female; mean age 55 years) who had undergone head and neck microvascular free flap reconstruction. All patients underwent 64-slice CTA of the carotid artery. Post-processing with volume rendering reconstruction of CTA images was done. There was excellent inter-observer agreement (weighted kappa = 0.82, 95% confidence interval (CI) 0.74–0.93) in grading of the degree of vascular stenosis. The true sensitivity of CTA for diagnosis of stenosis of the vascular pedicle to the flap was 63% (95% CI 63–100%). Patients with failed flaps showed complete occlusion ($n = 2$) on CTA and underwent a replacement flap procedure. Patients with failing flaps showed severe stenosis ($n = 6$) of the vascular pedicle on CTA and underwent revision surgery. There was no change in the degree of stenosis on follow-up CTA for patients with moderate stenosis ($n = 9$). CTA is a reliable, non-invasive, high-quality imaging tool for the diagnosis and grading of vascular stenosis of the vascular pedicle of head and neck microvascular free flaps.

Key words: CT; vascular; stenosis; head and neck; flap.

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The microvascular free flap is currently the most common choice for reconstruction in patients with defects following head and neck cancer surgery. The early detection of occlusion and stenosis of the vascular supply to the flap is important for salvage of the flap. If this occurs early, vascular reanastomosis of the flap may be successful. If there is a delay, a new flap will be required.[1–5]

Different invasive and non-invasive methods have been used for the assessment of the microvascular flap.[6,7] An implantable Doppler probe is used by the surgeon for the initial diagnosis of the vascular supply to the flap.[8] Colour duplex ultrasonography is regarded as an initial screening tool in the evaluation of the postoperative flap. However, this is operator-dependent and only has a small field of view.[9] Tissue oxygen measurements and positron emission

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tomography (PET) are used to predict ischaemia in the microvascular free flap, but these modalities are expensive and often unavailable.[10,11] Perfusion computed tomography (CT) has been used to assess the viability of the microvascular flap, but it cannot evaluate the site of vascular anastomosis and is associated with high radiation exposure.[12,13] Digital subtraction angiography is the gold standard for assessment of the degree of stenosis of the carotid artery, but it is an invasive and potentially harmful procedure.[14] Therefore, there is a need for a non-invasive imaging modality for the assessment of the vascular anastomosis of microvascular flaps of the head and neck.

In recent years, CT angiography (CTA) has been established as a non-invasive standard procedure for vascular imaging.[15–17] Several studies have discussed the role of CTA as a reliable modality for the planning of microvascular reconstructions of the head and neck.[18–20] Considering the success of CTA in evaluating coronary and limb arterial by-pass grafts,[21,22] the proposal of utilizing CTA for the evaluation of vascular stenosis of the vascular pedicle at the anastomotic site of head and neck microvascular flaps has some merit. To our knowledge, only one study in the English language literature has discussed CTA in this context, and this involved the case of a single patient with a haemorrhage after head and neck microvascular flap reconstruction.[23]

The aim of this study was to evaluate the role of CTA in the diagnosis of vascular stenosis at the vascular pedicle of head and neck microvascular free flaps and its impact on patient management.

Materials and methods

A prospective study was done of 65 consecutive patients (49 males and 16 females with a mean age of 55 years, range 18–74 years) who had undergone a microvascular free flap reconstruction in the head and neck region. All patients underwent CTA as a part of diagnostic workup after flap surgery. Two patients presented with pale and cold flaps and underwent an urgent CTA on the second day after surgery. Six patients with rapid progressive changes in colour and temperature of the flap underwent CTA on days 4–6 after surgery. The remaining patients ($n = 57$) underwent CTA on days 10–14 after surgery.

The donor flaps were free jejunal ($n = 25$), free fibular ($n = 12$), free iliac crest ($n = 10$), free radial forearm ($n = 9$), and free anterolateral thigh ($n = 9$) flaps. These flaps were used for pharyngeal ($n = 25$), mandibular ($n = 20$), and skin or soft tissue ($n = 18$) reconstruction. The feeding artery to the microvascular free flap was the superior thyroid artery ($n = 25$), facial artery ($n = 17$), lingual artery ($n = 13$), and superficial temporal artery ($n = 10$). An urgent reflap procedure was done for two patients, revision surgery was performed for six patients, and a follow-up CT scan was done for nine patients with moderate stenosis. Hospital review board approval was obtained and informed consent was obtained from the patients.

All patients underwent CTA using a 64-slice multidetector CT scanner (Brilliance 64; Philips Medical Systems, Cleveland, OH, USA). The CT examination was performed in supine position with the patient's arms to the sides of their body. The examination started with a low-dose unenhanced acquisition to localize the flap and to focus the CTA volume. The parameters for this acquisition were 80 kV, 180 mA, pitch of 1, and section thickness of 1.5 mm. The bolus triggering technique was used for timing of the contrast medium injection (350 mg iodine/ml). A region of interest (ROI) was centred on the upper end of the common carotid artery and sized to include only the lumen of the artery. The bolus triggering technique started automatically after contrast medium injection, as soon as an attenuation value of 100 Hounsfield units (HU) was reached in the ROI. Non-ionic contrast medium (0.5 ml/kg) was injected at a rate of 4 ml/s via single-head power injector (EnVision CT Injector; MEDRAD, Pittsburgh, PA, USA), with a 20-G intravenous cannula in the antecubital fossa of either upper extremity. The CT parameters for arterial acquisition were 120 kV, 300 mA, pitch of 1.35, and section thickness of 0.75 mm. The imaging datasets were reconstructed using three-dimensional volume rendering (VR) imaging. Bone subtraction was done in 24 patients when the bone masked the underlying site of the anastomosis. The images were transferred to a workstation.

Image analysis was performed by one neuroradiologist (AA) with 25 years of experience and one head and neck vascular surgeon (AD) with 28 years of experience. The images were reviewed independently and the degree of stenosis at the vascular anastomosis measured; both clinicians were blinded to the patient data. The site of the vascular anastomosis was determined as the region where the feeding pedicle artery met the artery of the flap. The degree of stenosis of the vascular pedicle at the vascular anastomosis in comparison to the proximal feeding artery was measured on a workstation using an electronic calliper. The degree of stenosis was graded into subtle stenosis (less than 10%), mild stenosis (10–25%), moderate stenosis (25–74%), severe stenosis (75–99%), and complete occlusion (100%). The course of the vascular pedicle of the flap was determined.

Statistical analysis of the data was done using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). The weighted kappa statistic (κw) with 95% confidence interval (CI) was used to estimate the grading of the vascular stenosis of the vascular pedicle at the site of the vascular anastomosis. The κw values were interpreted as follows: κw values between 0.00 and 0.20 represented poor agreement; between 0.21 and 0.40 represented fair agreement; between 0.41 and 0.60 represented moderate agreement; between 0.61 and 0.80 represented good agreement; and between 0.81 and 1.00 represented excellent agreement. The sensitivity of CTA for the diagnosis of stenosis at the vascular anastomosis was calculated.

Results

All CTA examinations were performed successfully. All contrast injections were performed safely, and no adverse reactions or complications occurred during or after the CTA procedure. For reader 1, CTA revealed complete occlusion of the vascular pedicle at the site of the vascular anastomosis for two patients (Fig. 1), severe stenosis for six, moderate stenosis for nine (Fig. 2), mild stenosis for 20 (Fig. 3), and subtle stenosis for 28. For reader 2, CTA revealed complete occlusion for two patients, severe stenosis for six, moderate stenosis for nine, mild stenosis for 25, and subtle stenosis for 23. There was excellent agreement ($\kappa w = 0.82$, 95% CI 0.74–0.93) between the readers in grading the vascular stenosis of the vascular pedicle at the site of the vascular anastomosis.

Management and surveillance of the flap depends upon CTA findings. The patients who presented pale and cool flaps in the first 2 days after surgery underwent urgent CTA. There was complete vascular occlusion with no contrast flow to the vascular pedicle of the flap on CTA. These two patients underwent an urgent reflap procedure. After this reflap procedure, the flaps were hot and red in colour. Six patients presented with early progressive rapid changes in the colour and temperature of the flap within 5–7 days after surgery. In these patients, CTA revealed