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Cosmetic medicine has recently shown interest in the use of Doppler ultrasound (DUS) analysis of the face because of the apparent advantage this technique offers in the prevention and treatment of complications. DUS is the easiest way to detect the presence of previously injected fillers and their complications. It can be used in office-based settings, producing real-time feedback from visual and palpable observations. Most types of fillers, either resorbable or nonresorbable, can be distinguished.1-12 Threads can also be visualized.13 The latest higher-frequency probes produce better-quality imaging, offering opportunities to acquire more detailed information about currently unobservable aspects of filler treatments, eg, detection of their in situ behavior.14 A specific nomenclature to describe the in situ properties of fillers has been proposed.15

DUS offers the potential to detect arteries, which can then be avoided when injecting.16 Individual variations are

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known to exist and may also be acquired after trauma, surgery, or nonsurgical procedures of the face. In case of hyaluronic acid filler complications, DUS enables the practitioner to precisely deliver ultrasound-guided injections intralesionally.\textsuperscript{9,17,18} In addition to treatment and prevention of complications, DUS can give the physician a 3-dimensional (3D) insight into subcutaneous anatomy, presenting an opportunity to aim for a specific injection plane. The increasing popularity of DUS has been assisted by the appearance of a number of low-priced portable devices that have become available during the past few years. However, most practitioners in cosmetic medicine are not familiar with the use of ultrasound. There has been a call for standard ultrasound transducer positions in DUS examinations to make things easier when starting to use the equipment and to assist with interpretation of the images. This study attempts to realize this. Part 1 presents static anatomy with ultrasound images; part 2 discusses images of vascular structures obtained with color Doppler ultrasound (duplex mode).

\textbf{Transducer Positioning}

The 3 different standard planes of imaging are termed transversal, sagittal, and coronal (Figure 1). All transducers (also named probes) have a one-sided marking that should point to the patient’s right ear in the cranial orientation. The right side of the patient then corresponds with the right side of the image on the screen. In the sagittal orientation the marking should point to the cranium, which then delivers the upper part of the face on the left side of the screen. Deviations from these nonstandard directions are named after the closest standard plane, eg, semisagittal or semicoronal. Handling of the transducer gives 3 degrees of freedom: tilt or angulation, rotation, and shifting or gliding (Figure 2).

\textbf{Recognition of Different Structures}

Ultrasound devices produce an image composed of various tones of gray. In-depth descriptions can be found in textbooks.\textsuperscript{19,20} In short: absent reflection of sound waves is depicted as black (anechoic), and complete reflection as white (hyperechoic). In between are various shades of gray (hypoechoic). In some instances a structure has the same echogenicity as the surrounding structures (isoechoic), but can be recognized as a separate entity because of the distortion of the tissue architecture or of its internal structure. Internal structures may be either homogeneous or heterogeneous.

Vascular structures are most easily recognized in Doppler mode. With this modality the flow of blood is given in red (towards the probe) or blue (away from the probe). Care must be taken during examination not to impede blood flow by pressing too hard on the skin with the probe. This will hinder venous flow in particular. To avoid this, ample use of ultrasound gel is advocated.

Images of the most common tissue types in the face are given in Figure 3 (dermis, subdermis, fascia, muscle, bone). The dermis is a small hypoechoic band. The subdermal area contains different structures, being either fat (hypoechoic mass), blood vessel (anechoic round to oval; see Figure 4), or fibrous tissue (short hyperechoic streaks). Muscles contain a vast amount of water (blood) and are therefore hypoechoic structures. Larger muscles are interspersed with small tendon sheets. Bone and fascia are dense hyperechoic structures. Nerves are too small to visualize with the devices commonly available.

\textbf{Principles of Facial Orientation}

It is important to realize that DUS is not like reading a series of pictures from standardized sections of the face, as is the case in computed tomography scans, magnetic resonance imaging, X-ray images, etc. DUS is a dynamic tool aimed at gaining insight into the spatial relation of the anatomic structures in a face. DUS allows us to visualize in our mind a 3D image of the patient’s face. It
is, for instance, not only important to see how far away from the nasolabial fold the facial artery is in the lateral plane; it is just as important to know how deep under the skin surface the artery runs. In addition, the assessment of depth of the superficial musculoaponeurotic system (SMAS) on the cheeks, the inferior part of the orbicularis oculi muscle, or the location of the infraorbital foramen may be of importance for diverse reasons. With DUS it is all about the relation of variable anatomic structures to fixed ones. Therefore, at the start of any facial ultrasound...
examination, it is reasonable to begin with identifying a number of fixed structures as points of reference and from there explore the regions.

**Standard Ultrasound Transducer Positions in the Face**

For every area in the face we define a set of standard positions with a predefined orientation of the ultrasound transducer. In these positions fixed anatomic structures (reference points) can be found easily. With small movements of the ultrasound transducer other important structures can be identified and ultimately a 3D image of the area can be composed. The patient provided written consent for the facial examination. The examinations and study were conducted in accordance with guidelines of the Declaration of Helsinki as they are included in our standard of patient care.

**Position 1: Jawline (Figure 4A-C)**

- Transducer position: axial halfway along the edge of the mandibula along the mandibular ramus inferior border. Slide anteriorly and cranially
- Reference point: masseter muscle (the facial vein and artery can be identified at the medial border of the masseter muscle)

The masseter muscle is an hypoechoic structure interspersed with hyperechoic fibrous sheets. The muscle delineates the lateral boundary of the face. Its medial edge marks the crossing of the facial vein over the mandible. Directly anterior to the vein lies the facial artery. More cranially, the facial artery lies on top of the buccinator muscle, visible as a deeper dark band running to the modiolus of the mouth, which being fibrous is therefore hyperechoic. On top of the masseter muscle the parotid gland extends cranially as a homogeneous, slightly hypoechoic structure. The distance of the parotid gland and the skin can be appreciated; in some patients this distance is less than 1 mm and precautions should be taken with filler injections. The SMAS can be visualized as a hyperechoic fibrous sheet on top of the masseter and may be followed all the way up.

**Position 2: Chin and Lower Lip (Figure 5A-C)**

- Transducer position: axial from midchin laterally. Slide and rotate to identify structures
- Reference point: depressor anguli oris (DAO) muscle

The DAO can be seen as an hypoechoic oval structure, emerging from the modiolus and running to the inferior part of the mandibula. Underneath, the depressor labii inferior muscle and the inferior labial artery can be seen. The mental muscle can be seen more medially on both sides of the midline on the mandibula. From the modiolus the inferior part of the orbicularis oris muscle can be identified. The mental foramen presents as a small gap in the chin bone about 1.5 cm above
the jawline and should be avoided when administering filler injections.

**Position 3: Upper Lip (Figure 6A-C)**

- Transducer position: axial on the vermillion part of the upper lip with cranial sliding movement towards the nose
- Reference point: orbicularis oris muscle and teeth

The orbicularis oris muscle presents as a hypoechoic band. Beneath this, teeth are seen as individual hyperechoic elements. The superior labial artery, and in the midline the columellar artery, can be found. In this area the subdermis is much less fibrous and more homogeneous hypoechoic with only small hyperechoic elements.

**Position 4: Midface (Figure 7A-C)**

- Transducer position: semisagittal from zygoma to the corner of the mouth, sliding to the nose
- Reference point: zygomaticus major muscle

This position delineates the lateral border of the midface area, the medial border being the nose. The zygomatic
muscle can be seen as a hypoechoic (linear) band running from the zygomatic arc to the modiolus of the mouth. It lies underneath the superficial medial cheek fat compartment and delineates the deep malar medial fat compartment and the buccal fat compartment. Medial to the zygomatic muscle the levator labii muscles and the infraorbital notch (a small gap in the maxillary bone) are found. From here, the infraorbital artery emerges. Close to the nose (Figure 8) is the angular artery, giving off the lateral nasal artery to the alar nasi. These structures should be taken into account and avoided during injections.

Position 5: Nose (Figure 8A-C)
- Transducer position: sagittal from glabella to tip of the nose, sliding movements up and down and to either side of the nose
- Reference point: nasal bone and cartilages
In the midline the deepest plane of the ultrasound image shows the hyperechoic nasal bone, with thin anechoic muscular structures directly on top. Above that is hypoechoic subcutaneous tissue extending caudally the slightly more hypoechoic nasal cartilage. Procerus and nasal muscles are thin hypoechoic ovals or lines. The lateral nasal arteries, dorsal nasal arteries, and intercanthal veins can be found. Lateral injections of the nose are at an increased risk for intra-arterial product application due to the presence of the terminal branch of the anterior ethmoidal artery.

Figure 6. Position 3: upper lip. (A) Probe position: axial (horizontal) on the vermillion part of the lip. (B) Anatomy: modiolus, m. orbicularis oris, teeth, superior labial vein and artery, columellar artery. (C) Ultrasound image: subcutaneous tissue (asterisk), modiolus (triple asterisk) extending into the orbicularis oris muscle, and teeth (arrows).
Position 6: Temporal Area (Figure 9A-C)

- Transducer position: sagittal at the hairline, sliding upwards and medial to the eyebrow
- Reference: temporal muscle

The temporal region (Figure 9) is built up from different layers of hypoechoic temporal muscle and multiple hyperechoic fascia sheets. From superficial to deep we can identify (1) epidermis, (2) dermis and (3) subcutaneous fat, (4) the hyperechoic SMAS or temporoparietal fascia, which is a continuation of the galea aponeurotica positioned on top of the (6) deep temporal fascia with (5) loose areolar tissue in between. The deep temporal fascia splits to harbor the deep temporal fat
垫位于7号区域的深层。7号区域的动脉包括外侧的颞动脉和额动脉。额动脉在额骨和肌肉的位置。

**DISCUSSION**

超声的使用在医学教育中越来越受到重视，这从某些医学院的点对点超声课程的整合可以看出来。超声的使用在许多医疗专业领域都得到了增长。然而，医学学生在课程中仍然缺乏超声应用的培训。在填充剂注射时，应标记并避免这些血管。

图8. 5号位置：鼻子。

- 探头定位：从眉间到鼻尖的矢状位。
- 解剖结构：鼻肌、鼻骨（上部）、鼻中隔、鼻侧动脉和静脉。

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**Position 7: Forehead (Figure 10A-C)**

- 探头定位：由眉间到鼻尖的矢状位，滑动沿内侧/外侧和颅部。
- 参考：额骨和肌肉

超声可观察的结构包括额部的同侧、皱眉肌和眉弓血管，这些血管应标记并避免在填充剂注射时使用。

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learn their anatomy from cadaver dissections. That will probably never change. In fact, in order to understand the images ultrasound offers, a good knowledge of facial anatomy is required. But ultrasound may offer another way to understand the interrelation of anatomic structures. It can help to gain a 3D insight with the patient sitting right beside the doctor, making it easy to image the relevant anatomy when performing filler treatment. However, one has to invest time and money when introducing DUS into daily practice.

Figure 9. Position 6: temple. (A) Probe position: sagittal (vertical) in hairline. (B) Anatomy: temporal muscle fills the temporal fossa. On top of the muscle are 2 fat pads and several fibrous sheets, and frontal branches of the superficial temporal artery and the vein. (C) Ultrasound image from top to bottom: epidermis/dermis (1), superficial fat pad (between 1 and 2), superficial temporal fascia (2), loose areolar tissue (between 2 and 3), deep temporal fascia (superficial layer) (3), superficial temporal fat pad (4), deep temporal fascia (deep layer) (5), temporal muscle (6), bone (under 6)
CONCLUSIONS

The increased interest in DUS examination of the skin has been boosted by both affordable handheld devices and the emergence of high-frequency devices (18 MHz and higher). These machines will give increasing levels details in superficial imaging. In the future, this may change the way in which cosmetic filler treatments are performed. In addition to cosmetic medicine, DUS imaging holds great promise for anatomy, dermatology, and plastic surgery in a broader sense. With this technology a new area of research may unfold in these specialties.
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Disclosures
Dr Kadouch is consultant for Merz Pharma (Frankfurt, Germany). Dr Schelke, Dr Velthuis, and Dr Jansen are trainers for Cutaneous, facial ultrasound (Noord, Holland). Dr Cotofana is consultant for Merz, Allergan (Noord, Holland), and Galderma (Lausanne, Switzerland). Dr Ascher is Scientific Director of the IMCAS.

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