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ORIGINAL PAPERS

The Assessment of the Vascular Risk for Facial Procedures using Thermal Scanning Imaging and Doppler Ultrasonography

Daniela Elena Gheoca MUTU^{1,2}, Laura RADUCU^{2,3}, Adelaida AVINO^{2,3}, Florin Teodor BOBIRCA^{4,5}, Cosmin-Marian PANTU¹, Iulian Alexandru DOGARU^{1,6,7*}, Iulian SLAVU¹, Abdalah ABU BAKER^{2,7}, Florin Mihail FILIPOIU¹, Cornelia NITIPIR^{8,9}

Abstract

Introduction: Surgical and non-surgical facial procedures have gained immense popularity thanks to their aesthetic benefits. Understanding the vascularization of the face and assessing potential risks is crucial to ensure patient safety and optimal outcomes. This study aims to evaluate the utility of thermal scanning and Doppler ultrasonography in evaluating the vascular risk for facial procedures. **Material and Methods:** A cohort of 60 patients were included in this prospective study. Preoperative thermal scanning and Doppler ultrasonography were performed in order to visualize the facial vasculature and identify potential areas of risk. **Results:** For 30 patients, we performed preprocedural Doppler ultrasound imaging and thermal scanning at the injection site. Only 6.66% of them suffered vascular complications, whilst 23.33% among those who didn't undergo ultrasound and thermoscaning suffered vascular injuries. The combined use of these tools proved to be valuable in assessing the vascular risk for facial procedures. The findings emphasize the importance of preoperative assessment to identify patients at risk for vascular complications. **Conclusions:** Thermal scanning and Doppler ultrasonography offer a comprehensive approach to assessing the vascular risk for facial procedures. By ensuring the identification of abnormal vascular patterns and altered blood flow dynamics, these techniques enhance patient safety and procedure planning.

Keywords: Doppler ultrasound; facial injectology; aesthetic procedures; thermal scanning; facial vessels.

Rezumat

Introducere: Procedurile la nivelul feței, fie ele chirurgicale sau non-chirurgicale, au căpătat o imensă popularitate, datorită beneficiilor estetice pe care le aduc. Înțelegerea vascularizației feței și analizarea posibilelor riscuri sunt cruciale pentru siguranța pacienților și pentru rezultate optime. Studiul nostru își propune să evalueze utilitatea scanării cu camera termală și a ecografiei Doppler în evaluarea riscului vascular în cadrul procedurilor estetice faciale. **Material și metodă:** Acest studiu prospectiv include o cohortă de 60 de pacienți. S-au practicat, preoperator, scanare cu camera termală și ecografie Doppler pentru a putea vizualiza traiectele vasculare ale feței și identifica posibilele zone de risc.

¹Department of Anatomy, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

²Plastic and Reconstructive Surgery, "Prof. Dr. Agrippa Ionescu" Clinical Emergency Hospital, Bucharest, Romania

³Department of Plastic and Reconstructive Surgery, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

⁴Discipline of Surgery, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

⁵Department of Surgery, "Dr. Ion Cantacuzino" Clinical Hospital, Bucharest, Romania

⁶Department of Surgery, "Prof. Dr. Agrippa Ionescu" Clinical Emergency Hospital, Bucharest, Romania

⁷Doctoral School, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

⁸Discipline of Oncology, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

⁹Department of Oncology, "Elias" Emergency University Hospital, Bucharest, Romania

*Corresponding author:

Iulian Alexandru DOGARU, Department of Anatomy, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

E-mail: iulian-alexandru.dogaru@drd.umfcd.ro

Rezultate: Pentru 30 dintre pacienți, am efectuat investigațiile imagistice în vecinătatea locului de injectare. Doar 6.66% dintre ei au suferit complicații vasculare, în timp ce 23.33% dintre pacienții pentru care nu s-au practicat investigațiile au prezentat astfel de complicații. Utilizarea ambelor instrumente s-a dovedit a fi extrem de valoroasă în aprecierea riscului vascular pentru procedurile faciale. Rezultatele noastre evidențiază importanța unei atente analizări pre-operatorii, cu scopul identificării pacienților cu risc de complicații vasculare. **Concluzii:** Scanarea cu camera termală și ultrasonografia Doppler oferă o manieră optimă de analizare a riscului vascular în procedurile estetice de la nivelul feței. Prin certificarea și identificarea traseelor vasculare anormale și a modificărilor dinamice ale fluxului sangvin, aceste procedee diagnostice asigură siguranța în ceea ce privește siguranța pacienților și planificarea intervențiilor.

Cuvinte cheie: ultrasonografie Doppler, injectologie facială, proceduri estetice, scanare termală, vase faciale.

INTRODUCTION

One of the modern plastic surgeon's challenges is the very high demand to perform facial injection procedures for facial rejuvenation. The general public considers the techniques of injecting various substances into the face as risk-free procedures.¹ Consequently, the appearance of complications following these procedures is surprising for the patient and often leads to legal consequences.² The authorized practitioner is the one who understands the risk of each injection technique, knows how to manage it and knows how to present it to the patients in order to obtain their informed consent.³ The everyday reality shows that the plastic surgery specialist is under constant pressure from the extremely high demand to perform facial injection procedures. Although these procedures are globally called injection procedures, in reality every invasive operation carries the risk of damaging important facial structures and the appearance of various complications, which can sometimes end up putting the patient's life at risk. [4]

In facial injections, one of the major risks is the damage of the facial vessels. Such an incident results in either a hematoma or, in extreme cases, arterial or venous emboli. Consequently, knowing and correctly assessing the depth of the puncture in the territories traversed by arteries or veins is one of the success criteria for the respective manoeuvres.^{2,5}

Fortunately, complementary methods, comprised of non-invasive investigations such as Doppler ultrasound, respectively the use of a thermal scanning imaging camera, represent an invaluable aid for the practitioner.^{6,7}

The thermal scanning of the face is a recent means of investigation, the use of which has not yet been correlated with facial injection techniques. In principle, thermoscaning highlights facial structures by providing a color-scaled appearance of the face, quantifying

well-vascularized, at-risk areas with higher temperature compared to surrounding regions.^{8,9}

The Doppler ultrasound is a reliable and easy-to-use exploration that can be successfully used at all procedural stages, both before and during injections to avoid vascular risk and ensure correct placement of volumizing substances. It can also be used post-procedurally to detect possible complications or for the correct introduction of hyaluronidase, the substance that degrades the hyaluronic acid introduced inappropriately.⁷

MATERIALS AND METHODS

A diverse cohort of 60 patients scheduled for facial procedures were included in this prospective study.

For 30 of the patients, preoperative thermal scanning images were obtained to visualize the facial vasculature and identify potential areas of increased vascularization. Doppler ultrasonography was also performed, in order to assess blood flow dynamics in the facial arteries and veins, providing information about the vascular architecture and potential vascular anomalies. We took note, for all 60 of the patients, of the vascular injuries that occurred and also of the existence of previous aesthetic procedures.

In our study, we used the FLIR E50 camera for thermal scanning, which has a sensor resolution of 240x180 physical pixels and a video camera of 3.1 megapixels, with an accuracy of $< \pm 2\%$ of the measured value, which records temperatures from -40 to $+650$. degree Celsius. We also used the portable SEEK Thermal XR camera that attaches to the mobile phone and has an infrared sensor resolution of 206 x 156 pixels and detects temperatures in the range of -40 to $+330$ °C.

The captured images were taken on a number of 30 volunteers and were performed at a constant ambient temperature of 24°C , from a distance of approximately 30 cm from the examined surface of interest, parallel to

the skin. Individuals were examined after thermal acclimatization of the body to environmental temperature and humidity had occurred.

The obtained images were downloaded without modifying any of the features of the software provided by the manufacturer (FLIR/SEEK).

We performed Doppler ultrasounds on a number of 30 volunteer patients (bilateral hemiface) and measured the distance between the vessel and the skin at the level of the facial vessels.

The examinations were carried out in specific regions for each procedure, and also for the facial artery for all of the patients. The evaluations were performed without compressing the underlying planes, for a more accurate assessment of the depth of the vessels. In this study we used an Esaote color Doppler ultrasound using a 7.5 MHz linear probe.

We performed data collection using Microsoft Office 2016 and statistical analysis using SPSS v.26.0. Chi-square test was used to assess the possible correlations within our data, with a p-value of less than 0.05 being considered as statistically significant.

RESULTS

The study cohort consisted of 11 males (18.33%) and 49 females (81.67%), with an average age of 32.38 years.

For 30 of the patients, we performed Doppler ultrasound imaging and thermal scanning in the injected region. For all 30 of them, we visualized the facial artery and observed its entire path at facial level. We also measured the distance between the artery and the surface of the tegument lateral to the modiolus, obtaining an average distance of 7.27 mm. Furthermore, for each of them we identified and took note of the path of the blood vessels in the region of the procedure, in order to avoid any vascular injury.

In our lot, 15 patients had previously undergone facial aesthetic procedures that may have modified the local anatomy (botulinum toxin injections, hyaluronic acid fillers or threads), suggesting vascular vulnerability in these regions.

Of the 30 patients who were investigated by imagistic means, only 6.66% (2 patients) suffered vascular complications (ecchymoses), whilst 23.33 (7 patients) among the 30 patients who didn't undergo ultrasound and thermoscanning suffered vascular injuries (4 ecchymoses, 2 hematomas and 1 vascular occlusion - of the inferior labial artery). Preprocedural evaluation implied

a significant difference in postinterventional complication rates $X^2(1, N = 60) = 4,32, p=0,038, \phi=-0,268$

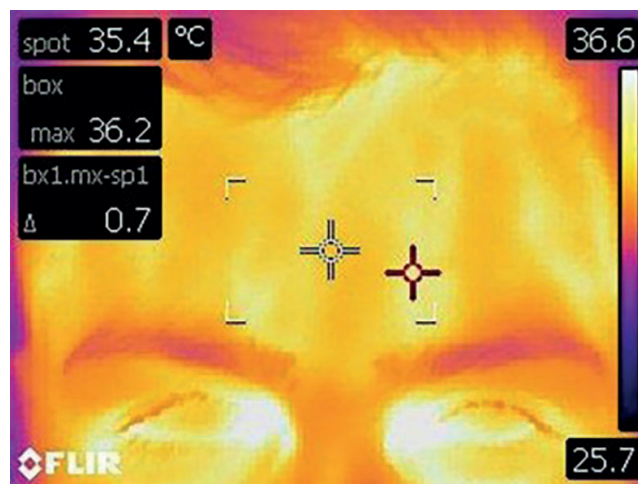


Figure 1. Thermal scanning imaging of the frontal and periorbital regions

In the upper part of the face, we can observe the vertical orientation of the temperature variations. The yellow areas overlap with the path of the supraorbital and supratrochlear vessels.

The information seems minimal, but in reality, we observe that the areas are symmetrical and wide enough to indicate the existence of well-represented and branched vessels that anastomose at the line of hair insertion.

On the midline, a much cooler area is seen, suggesting no vascular risk for the injection.

The root of the nose, in the glabellar area, is cold, indicating the absence of vascular pathways, while the medial angle of the orbit is warm. This area is highly vascularized.

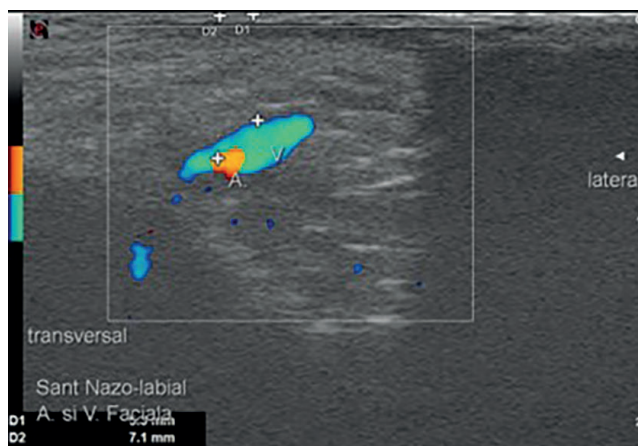


Figure 2. Doppler ultrasonography imaging of the facial artery in the nasolabial fold – transverse placement of the ultrasound probe

The facial artery can be explored through ultrasonography, using the probe in a transverse manner in the nasolabial groove, lateral to the ala of the nose. In this case, we measured a skin to artery distance of 7.1 mm, while the facial vein was detected at a depth of 5.3 mm.

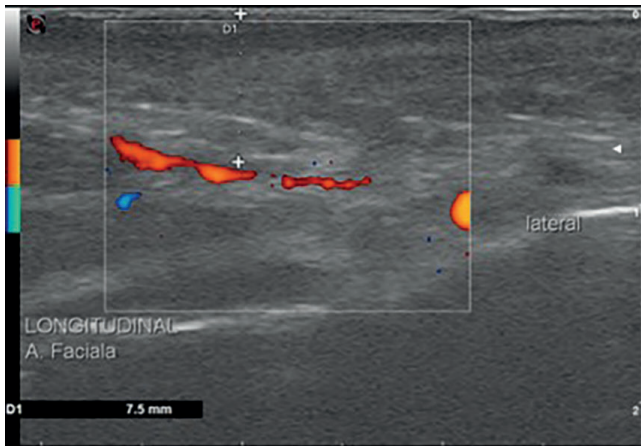


Figure 3. Doppler ultrasonography imaging of the facial artery in the nasolabial fold – longitudinal placement of the ultrasound probe.

Placing the probe in a longitudinal way in the nasolabial fold, we explored the depth of the facial artery along its path. For this patient, in the nasolabial fold, the distance between the artery and the skin was measured as 7.5 mm.



Figure 4. Ecchymosis caused by injecting the sentinel vein at the corner of the eye.

Aesthetic procedures that are currently widely used for facial rejuvenation can sometimes cause complications such as thrombosis, ischemia or the obstruction of regional arteries, such as the labial arteries. [3,10,11]

In most cases, the complications occur due to either incorrect technique, intravascular injection or intrafacial artery compression.

DISCUSSION

Based on our results, we developed a pre-procedural protocol for the assessment of the vascular risk of the face when performing cosmetic injections. It is an important step to ensure the safety and efficacy of the procedure. Therefore, a practitioner should:

Review the anatomy of the face: Before starting any cosmetic injection procedure, it is crucial to have a good understanding of the anatomy of the face, including the blood vessels and their location.

Assess the patient's medical history: Review the patient's medical history, including any previous surgeries, allergies, or medical conditions that could increase the risk of vascular complications.

Perform a physical examination: Conduct a thorough physical examination of the patient's face, paying close attention to the location of blood vessels and any visible signs of vascular compromise.

Use thermal scanning imaging: Use thermal scanning imaging to assess the temperature of the skin and identify any areas of inflammation or increased blood flow. This can help identify potential areas of vascular risk.

Use Doppler ultrasonography: Use Doppler ultrasonography to identify the location of blood vessels and assess their blood flow. The ultrasound examination is useful in both identifying the areas that have a compromised vascularization and ensuring that the procedures are performed safely.

Develop a treatment plan: Based on the results of the physical examination, thermal scanning imaging and Doppler ultrasonography, develop a treatment plan that takes into account the patient's anatomy, medical history, and potential risk factors for vascular complications.

Educate the patient: Before the procedure, educate the patient on the potential risks and benefits of cosmetic injections, including the risk of vascular complications. This will help ensure that the patient understands the procedure and can make an informed decision.

Monitor the patient: During the procedure, monitor the patient closely for any signs of vascular compromise. If any issues arise, take immediate steps to address them.

By following these steps and developing a pre-procedural protocol that incorporates thermal scanning imaging and Doppler ultrasonography, we can help ensure that cosmetic injections are performed safely and effectively, with minimal risk of vascular complications.

In our study, the average depth of the facial artery lateral to the modiolus was 7.27 mm. By comparison, Ten et al. measured a distance between 8.36 mm and 9.20 mm.¹² These data suggest that there is a high variability in terms of depth, which makes the use of ultrasound imaging the most reliable tool when performing facial filler injections in the nasolabial fold.

Thermal scanning has proven to be extremely useful in the assessment of the highly variable trajectory of the vascular elements of the face.

Despite their certain benefits, both means of investigation also have their downsides, the most important being the high cost of equipment, the learning curve the practitioner needs in order to become acquainted with the tools and the increase in the total time needed to perform the specific procedures.

CONCLUSION

Thermal scanning imaging and Doppler ultrasonography offer a comprehensive approach to assess the vascular risk for facial procedures. By ensuring the identification of abnormal vascular patterns and altered blood flow dynamics, these investigations enhance patient safety and procedure planning. Surgeons can use this information to minimize the risk of vascular complications and optimize results, leading to higher patient satisfaction and improved clinical outcomes.

Incorporating these advanced imaging modalities into the preoperative assessment protocol has the potential to revolutionize the field of facial procedures, setting new standards for patient care and procedural excellence. Further research and clinical validation are warranted to solidify the role of thermal scanning imaging and Doppler ultrasonography in enhancing the safety and efficacy of facial interventions.

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