

# Digital Infrared Thermal Imaging Assistance for Laryngectomy and Neck Dissection Flap Monitoring in Elderly Patients

## Yaşlı Hastalarda Larenjektomi ve Boyun Diseksiyonu Flep İzlemede Dijital Kızılötesi Termal Görüntüleme Yardımı

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### Abstract

**Objective:** In flap survival, close postoperatively monitoring of neck flaps is essential; instant action increases the rate of flap salvage. The purpose of this research was to assess the ability of digital infrared thermal imaging and software during laryngectomy and neck dissection monitoring to detect failure of neck flaps.

**Methods:** Twelve elderly patients who required total laryngectomy and bilateral neck dissection for advanced laryngeal cancer participated in this study. The hourly clinical examination of skin colour, capillary refilling and turgor were evaluated for both flaps. In addition, thermal images were taken synchronously with the digital camera. Such images were processed and analyzed as an indication of flap failure on their additional value.

**Results:** Out of 12 flaps, one failed due to hematoma, and venous congestion formed in two flaps. The mean flap temperature demonstrated to be most predictive of flap failing relative to the adjacent control skin. In contrast to the uncompromised flaps, both failed flaps demonstrated lower temperatures after failure.

**Conclusion:** An efficient thermal camera imaging can possibly improve post-operative flap monitoring. It could play an additional part in the non-invasive early diagnosis of flap failure if used in conjunction with other modalities. By analyzing relative differences in temperature between the flap and reference tissue, vascular occlusion in flaps may be differentiated.

**Keywords:** Thermal camera, flap monitoring, laryngectomy, neck dissection

### Öz

**Amaç:** Flep hayatta kalmasında ameliyat sonrası boyun fleplerinin yakın takibi önemlidir; anında harekete geçme flep kurtarma oranını artırır. Bu araştırmanın amacı, dijital kızılötesi termal görüntüleme ve yazılımın larenjektomi ve boyun diseksiyonu izlemi sırasında boyun fleplerinin başarısızlığını tespit etme yeteneğini değerlendirmektir.



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## Öz

**Yöntem:** Total larenjektomi gerektiren 12 yaşlı hasta ve bilateral ileri evre larenks kanseri için boyun diseksiyonu yapılan hastalar bu çalışmaya katılmıştır. Her iki flep için deri rengi, kapiller dolum ve turgor saatlik klinik muayeneler ile değerlendirildi. Ayrıca termal görüntülemeler de çekildi. Dijital kamerayla eş zamanlı olarak, bu tür görüntüler, flep başarısızlığının bir göstergesi olarak kaydedilerek analizleri yapıldı.

**Bulgular:** On iki flepten biri hematoma nedeniyle başarısızlıkla sonuçlandı ve iki flepte venöz konjesyon oluştu. Ortalama flep sıcaklığı, flep başarısızlığı açısından en tahmin edici veri olmuştur ve yanındaki kontrol derisine göre değerlendirilmiştir. Başarısız flepler başarısızlıktan sonra sağlam fleplere kıyasla daha düşük sıcaklıklar göstermiştir.

**Sonuç:** Verimli bir termal kamera görüntüleme, postoperatif flep takibinde daha yararlıdır. Diğer modalitelerle birlikte kullanıldığında, flep başarısızlığının non-invaziv erken teşhisinde ek bir rol oynayabilir. Flep ve referans dokusu arasındaki sıcaklık farkları analiz edilerek, fleplerde vasküler oklüzyon ayırt edilebilir.

**Anahtar Kelimeler:** Termal kamera, flep monitörizasyonu, larenjektomi, boyun diseksiyonu

## Introduction

Flaps have been commonly used over the decades for the repair or coverage of significant defects and the removal of tumours. Part of the flap circumference is completely isolated from the blood supply. Although apron flap success rate is high, due to circulatory failure, surgical revision is often required. Venous and arterial thrombosis are responsible for the majority of failures, usually occurring during the first 3 days<sup>(1)</sup>. The overall tolerable time for ischemia depends on type of flap. That being said, it is normally just a few hours before permanent tissue damage happens. It is mainly possible to monitor flaps by clinical examination. The explanation for these results; however, is highly reliant on the clinical experience of the healthcare staff<sup>(2)</sup>.

More advanced technical methods, such as handhelds Ultrasonography with Doppler, tissue oximetry have been practiced over the past years. These techniques have both advantages and disadvantages. One of the oldest measures of surface temperature is postoperative monitoring techniques. A body's emittance of infrared light is proportional to its temperature. A contactless approach for the surface temperature can be calculated. Some medical trials have shown that flap temperature can be associated with flap failure obtained with an infrared surface thermometer<sup>(3,4)</sup>. The objectives of this research was to determine the feasibility of combining the use of an infrared thermal digital camera with postoperative monitoring imaging tools to detect flap failure.

## Materials and Methods

This was performed in the Department of Otolaryngology at a Medical Tertiary Centre. The study was performed in accordance with the ethical standards of the Institutional and National Research Committee and was approved by

the Ethics Committee of University of Health Sciences Turkey, Antalya Training and Research Hospital (17<sup>th</sup> July 2020-protocol number 14/1). Additionally, patient consents were obtained. Twelve patients participated in this study who needed a total laryngectomy and bilateral functional neck dissection for advanced laryngeal cancer. All of the study group's patients were male and over 60 years of age. We performed the Apron flap incision described by Latyshevsky and Freund to all patients<sup>(5)</sup>. Only a horizontal incision gently curving inferiorly up to the upper border of the thyroid cartilage from mastoid to mentum was used bilaterally.

Every hour, postoperative flap monitoring was done on the first postoperative day and subsequent days 4 times a day by clinical examination of skin colour, capillary refilling and turgor. Normal mode digital photographs and thermal photographs were taken simultaneously with the Nikon D3100 DSLR Camera (made in Japan) and FLIR E8 (made in USA) high resolution infra-red thermal camera, respectively. Digital infrared thermal imaging was performed for the skin temperature mapping in automatic self-calibration mode. The spectral range of this camera lies between 7.5 and 13  $\mu\text{m}$ .

After a time of 5 minutes, the photographs were made in a room with a stable temperature of 25 °C, 60 per cent humidity, used to suit the room temperature and environmental conditions. On all available visual images, including thermal data from the actual thermal image, the entire flap and reference skin were demarcated. The thermal and visual images were verified and matched. As an indication of flap failure, these images were analyzed for their additional value.

## Statistical Analysis

Categorical variables are given as percentage distribution. Microsoft Excel and manual statistical formulas were used for analysis.

## Results

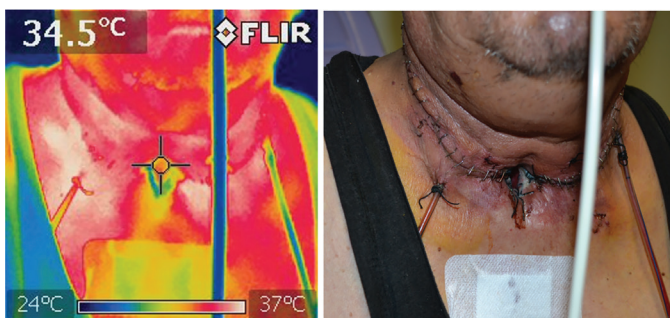
In order to find interrelationship between the thermal images, digital photographs and clinical findings flaps data were retrospectively analyzed. Of the 12 flaps, nine had no postoperative complications. The mean temperature for each point of time was measured to serve as the basis for examination and clinical signs (skin color, turgor, and capillary refilling) were reported for the healthy flaps.

Three of the flaps had postoperative complications. Two have shown clinical symptoms of venous congestion. The healthy flaps, according to both the reference point and the mean temperature, this finding was associated with the overall lower temperature of this flap, as shown in the Figure 1, drop in temperature difference from 0.5 °C to -1.5 °C was revealed by thermal data.

One flap presented 12 h postoperatively with discolored, purple regions. Moreover, in contrast to the top, the flap was pinker in the middle. Fluctuation was felt on palpation in this area. A decrease in temperature was already detected. Hematoma was drained from the incision edge and the hemovac drain was checked. In the following days the colour appeared to improve spontaneously.

## Discussion

Flaps have been widely used for the repair or coverage of critical defects and tumour removal. Apron flap is one of the most preferred incisions, especially in combination with total laryngectomy and neck dissection. An advantage of this flap is that it protects the descending arterial recovery and carotid artery. But the ascending arterial and venous recovery is impaired by this approach. Furthermore, the bottom corner



**Figure 1.** Clinical signs of venous congestion (figure right side). Compared to both the reference point and the mean temperature of the healthy flaps, this finding was associated with the overall lower temperature of this flap, as shown in (figure left side) a drop in temperature difference from 0.5 °C to -1.5 °C was revealed by thermal data

may develop venous congestion and oedema. Even though the success rate of the apron flap is high, surgical revision is rarely needed due to circulatory failure. The majority of failures, typically occurring within the first 3 days, are caused by venous (53-57%) and arterial thrombosis (20-43%)<sup>(1-3)</sup>.

By measuring capillary refilling, turgor, swelling, flap color and/or pinprick examination, monitoring of free flaps can be achieved mainly by clinical observation. The analysis of these findings, however, is highly reliant on the medical staff's clinical expertise. In recent years, more technologically advanced techniques have been performed, such as implantable Doppler ultrasonography, minimally invasive tissue oxygen tension or non-invasive oxygen saturation via near-infrared spectroscopy. Since both advantages and disadvantages are provided by each of these procedures, there is a possibility that someone or something will improve. Therefore, during the first critical 72 h after flap shift, there is a constant search for improved monitoring systems<sup>(3,5)</sup>.

One of the oldest techniques of postoperative monitoring is surface temperature analysis. This may be done either by putting a sensor directly on the skin or by using a contactless system to measure temperature. The purpose of our study was to determine the feasibility and potential of using a contactless method to monitor vascular failure detection in postoperative apron flap surveillance. Thermal imaging is an advanced scanning diagnostic device which measures the temperature by detecting infrared radiation from an object. Given that vascularization affects skin temperature, infrared thermography can also be used as reflection of the flow of cutaneous blood. The lack of radiation or intravenous contrast agents, readily accessible, relatively cheap, and also the fact that it is simple and easy to use, may be considered major advantages. It is even used as a mobile phone application today. It can also be used as an early warning sign of infection to evaluate subclinical inflammation<sup>(6,7)</sup>.

As a method for monitoring postoperative flaps used for elderly advanced laryngeal cancer patients, we have successfully used Thermal imaging. Venous blocking lead to blood congestion, which can lead to a temporary temperature increase<sup>(8)</sup>. If the pressure increases and the congestion persists, the flow of blood will decrease and remain static gradually. This led to tissue deoxygenation, hydrostatic pressure increase, and fluid leakage into the interstitium. Increased interstitial pressure, namely, oedema will suppress arterial inflow, causing steady temperature decreases<sup>(7-11)</sup>.

In our study, we took as reference healthy tissue around the flap at a stable room temperature of 25 °C. The majority of literature studies have indicated relating the mean flap temperature as a reference temperature to the adjacent skin. This will minimize the effects of environmental conditions that influence the temperature of the flaps, such as air flow or blanket coverage<sup>(9-13)</sup>.

### Study Limitations

The main limitation of this study that can be addressed and overcome in future research is the relatively limited sample size.

### Conclusion

Infrared thermography could be a modern, feasible, and non-invasive method of monitoring flap subcutaneous vascularization. In particular, it appeared to be useful in identifying failed flaps from healthy flaps by comparing the measured flap temperature difference to an adjacent reference position. Combination with other modalities, may play an additional role in the non-invasive early detection of flap failure.

### Ethics

**Ethics Committee Approval:** The study was performed in accordance with the ethical standards of the Institutional and National Research Committee and was approved by the Ethics Committee of University of Health Sciences Turkey, Antalya Training and Research Hospital (17<sup>th</sup> July 2020-protocol number 14/1).

**Informed Consent:** For this type of study informed consent is not required.

### Authorship Contributions

Surgical and Medical Practices: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I., K.Ç., Ö.E.G., Concept: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I., K.Ç., Ö.E.G., Design: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I., K.Ç., Ö.E.G., Data Collection or Processing: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I., K.Ç., Ö.E.G., Analysis or Interpretation: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I.,

K.Ç., Ö.E.G., Literature Search: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I., K.Ç., Ö.E.G., Writing: E.A.Ç., M.K., M.Y., G.Y., Ü.G.I., K.Ç., Ö.E.G.

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