Thermography of Facial Skin Temperature in Healthy Subjects During Cooling of the Face with Hilotherapy

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SUMMARY

Background: Hilotherapy (in which the face is cooled by a temperature-regulated, water-cooled mask at 15ºC) may be more effective than standard cryotherapy (using cold packs) in reducing swelling and pain after facial surgery. No data exist, however, on the speed of cooling during the application of the hilotherapy mask, and the actual skin temperatures achieved across the face are also unknown. We investigated a facial cooling procedure using a hilotherapy mask in 3 healthy control subjects using infrared thermography. In one of the subjects, we also studied cooling of the face using an ice compress.

Methods: The hilotherapy mask was applied to the face and set to cool in continuous mode at a temperature of 15ºC. Anterior, left lateral and right lateral thermograms of the face were recorded prior to cooling and 5, 10, 20 and 30 minutes after the commencement of the cooling procedure. The mask was briefly removed from the face to allow thermograms to be captured at each measurement time-point. A further set of thermograms was recorded 5 minutes after the cooling procedure had ended. After a 30 minute re-stabilisation period, the cooling process was repeated in one subject using the ice compress.

Analysis: Temperature data from the left lateral thermograms was plotted using four anatomical regions of interest (ROIs).

Results: The smallest drop in median skin temperature during the hilotherapy cooling procedure was observed at the most superior ROI (7°C), whereas the greatest drop in median temperature was recorded from the most inferior ROI (9.8°C). The maximum skin cooling achieved with the ice compress was 4.9°C (at the most inferior ROI).

Conclusions: Infrared thermography is an effective tool in the evaluation of facial cryotherapy for the reduction of pain and swelling after maxillofacial surgery. Our pilot data show that hilotherapy cools facial skin more effectively than an ice compress. The greatest skin cooling with hilotherapy over 30 minutes was achieved at the inferior part of the face. Further work is required with both healthy control subjects and surgical patients to determine the optimum cooling configuration with hilotherapy.

1. BACKGROUND

Facial cooling has been demonstrated to reduce pain and swelling after maxillofacial surgery, leading to im-proved patient satisfaction and shorter hospital stays. Maximal skin vasoconstriction occurs at a skin temperature of 15ºC (1). Rana et. al. (3) showed that hilotherapy (in which the face is cooled by a temperature-regulated, water-cooled mask at 15ºC) may be more effective than standard cryotherapy (using cold packs) in reducing swelling and pain after facial surgery.

Moro et. al. (2) found that hilotherapy was more effective at reducing swelling than ice-pack application in most areas of the face, but they found hilotherapy to be less effective in limiting swelling between the external canthus and tragus – an area not fully enclosed by the hilotherapy mask.

No data exist on the speed of cooling during the application of the hilotherapy mask, and the actual skin temperatures achieved across the face are also unknown.

In order to better understand the performance of hilotherapy, we monitored a facial cooling procedure using the hilotherapy mask in three healthy control sub-jects using infrared thermography. In one of the subjects, we also studied cooling of the face using an ice compress.

2. METHOD

Three healthy adult control subjects (1 female, 2 male) gave informed consent prior to participating in the measurements.
Each subject avoided smoking, hot food, alcohol and caffeinated drinks for one hour prior to the investigation, and rested in the thermography laboratory for 15 minutes at a room temperature of 23ºC prior to imag-ing. Thermography was performed using an A320G Thermacam imager (FLIR Systems, West Malling, UK) with an ethernet connection to a PC running FLIR Thermacam Researcher software. The A320G is an uncooled focal plane array imager sensitive across the 7-14 μm waveband. The thermal imager was recently quality-assured against a blackbody source traceable to the International Temperature Scale of 1990 (4). No camera readings differed from the source temperature by more than 0.3°C across the range of facial skin temperature. Prior to measurement, the thermal imager was operated for one hour to ensure the microbolometer detector gave stable temperature readings.
For each subject, the hilotherapy mask was applied to the face and set to cool in continuous mode at a temperature of 15ºC. Anterior, left lateral and right lateral thermograms of the face were recorded prior to cooling and 5, 10, 20 and 30 minutes after the commencement of the cooling procedure. The mask was briefly removed from the face to allow thermograms to be captured at each measurement time-point. A further set of thermograms was recorded 5 minutes after the cooling procedure had ended. After a 30 minute re-stabilisation period, the cooling process was repeated in one of the male subjects using the ice compress.
Fig. 1 shows a sequence of left lateral thermograms monitoring cooling using the hilotherapy mask in the female subject.

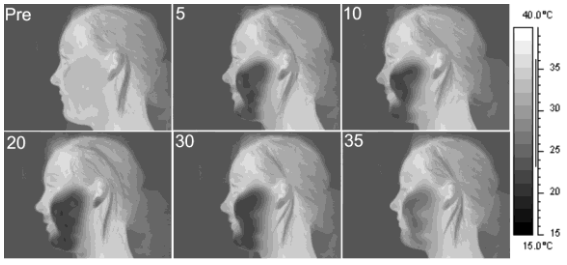

Fig. 1 - Thirty-minute cooling sequence using the hilotherapy mask in a female subject. The 35-minute time-point is 5 minutes after cessation of cooling.

3. ANALYSIS

Temperature data from the left lateral thermograms was plotted using four anatomical regions of interest (ROIs). These regions represented areas of anatomical significance when making the bone cuts for standard maxillary and mandibular osteotomies for orthognathic corrections. The ROIs were adapted from the linear measurements along the face made by Moro et. al. in their assessment of change in oedema and swelling in response to cooling. The four ROIs are shown in fig. 2. Region 1 was the most superior ROI, with region 4 being the most inferior.

4. RESULTS

Facial temperature from the four ROIs during the hi-lotherapy cooling procedure is plotted in figures 3 to 6. Data shown are median, maximum and minimum temperature from the 3 subjects. The 35-minute time-point was 5 minutes after the cessation of cooling. Skin cooling was observed at all four ROIs. For re-gions 1 to 3, maximum cooling occurred at 20 minutes and there was a subsequent small rise in skin temperature during the final 10 minutes of the cooling procedure. At region 4, skin temperature reduced throughout the entire 30 minutes of the cooling procedure. Compared to baseline, the smallest drop in median skin temperature during the cooling procedure was observed at region 1 (7°C), whereas the greatest drop in median temperature was recorded from region 4 (9.8°C). The lowest median skin temperature recorded was 24.3°C (after 20 minutes from region 2).

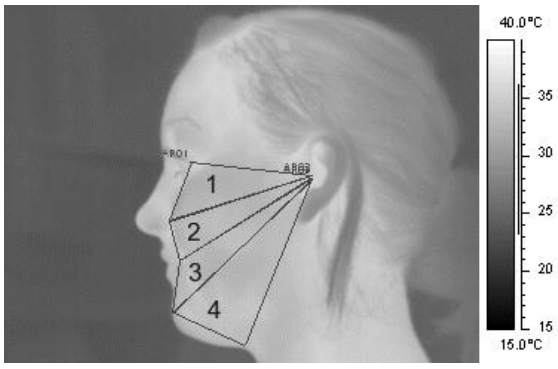

Fig. 2 - Four regions of interest for extracting temperature data from the thermograms.

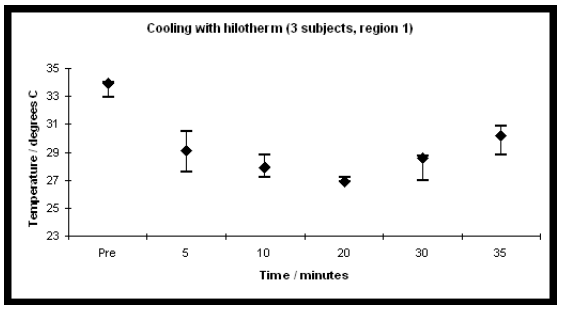

Fig. 3 - Cooling with hilotherm: 3 subjects, region 1.

Fig. 7 and fig. 8 show the skin temperatures for subject 3 during cooling with hilotherapy and an ice compress respectively. The maximum skin cooling achieved with the ice compress was 4.9°C (after 20 mins at region 4), compared to a maximum skin cooling of 10.2°C (after 30 mins, also at region 4) using hilotherapy. The maximum skin cooling achieved at region 1 using the ice compress was only 0.5°C.

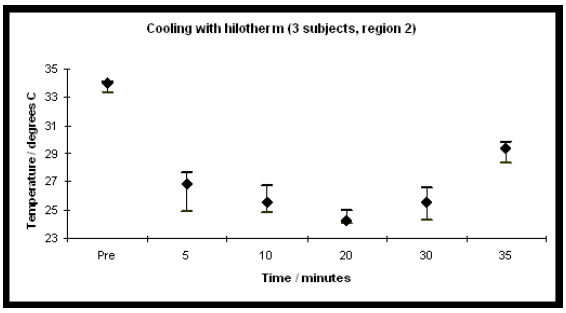

Fig.4 - Cooling with hilotherm: 3 subjects, region 2.

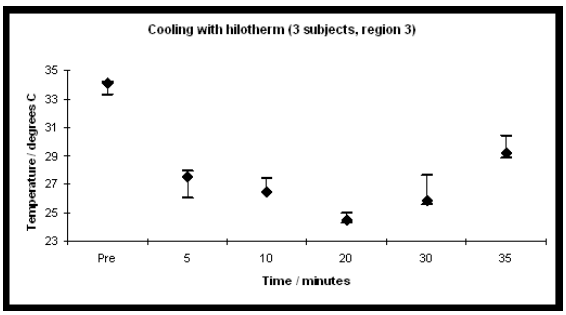

Fig. 5 - Cooling with hilotherm: 3 subjects, region 3.

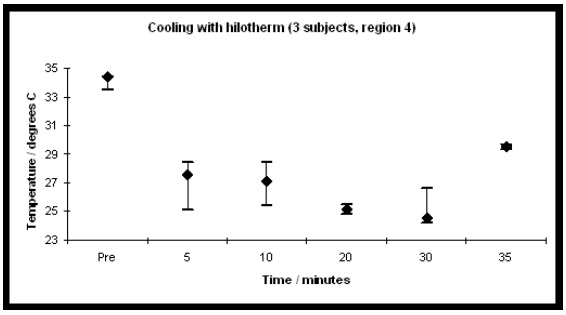

Fig. 6 - Cooling with hilotherm: 3 subjects, region 4.

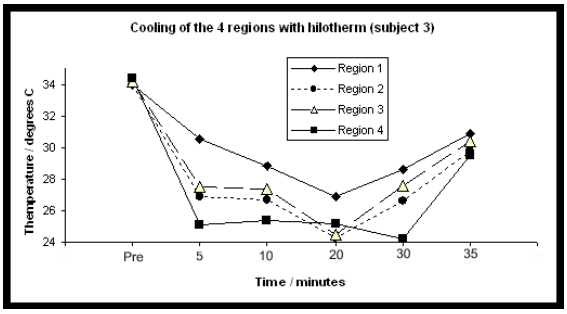

Fig. 7 - Thirty-minute cooling sequence using hilotherm in subject 3.

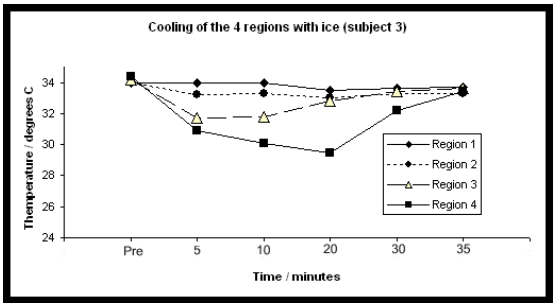

Fig. 8 - Thirty-minute cooling sequence using an ice compress in subject 3.

5. CONCLUSIONS

Infrared thermography is a useful method to monitor facial cooling with cryotherapy techniques. Our data show that hilotherapy cools facial skin effectively, particularly in the more inferior parts of the face. Our results from the most superior region of interest suggest that this area is cooled at least 2.5°C less than the three more inferior ROIs. This observation is in keeping with the findings of Moro et. al (2) that hilotherapy was less effective at limiting swelling between the external canthus and tragus (which is not an area entirely enclosed by the hilotherapy mask).

We saw evidence from ROIs 1 – 3 that, with the mask set to 15°C, maximal cooling is achieved at 20 minutes. After this time the skin temperature rose slightly, suggesting a process of autoregulation. At ROI 4, however, skin temperature continued to fall until cooling ceased at 30 minutes.

The lowest median skin temperature observed of 24.3°C was 9.3°C higher than the mask coolant water temperature; further work is required to investigate if lower coolant temperatures and/or longer cooling procedures could achieve lower skin temperatures.

In the subject who also underwent cryotherapy with an ice compress, hilotherapy was markedly more effective than the ice compress at cooling all facial skin regions.

The Hilotherm mask is a promising device for reproducible cooling of the face after maxillofacial surgery. Further work is now required in both healthy control subjects and surgical patients to investigate the opti-mum cooling configuration for hilotherapy.

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