

Development of a Colorimetric Scale as an Aid for Estimating Temperature of Burnt Bone



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Abstract: Background: Forensic pathologists, archeologists, and forensic anthropologists are often required to interpret burnt bones. One of the key factors for an accurate interpretation of the remains and the events leading to incineration is the estimation of the maximum exposure temperature of the human remains. Several types of research focus on temperature estimation, using color assessment, histology observations, and mechanical changes, which can help in the most accurate interpretation. The color of burnt bone is inevitably related to the time and temperature(s) to which it was exposed, the size and condition of the bone, and the environment. Nevertheless, it can be possible to estimate exposure temperature based on visual observation and analysis.

Objective: Development of a colorimetric scale for photographic documentation and the color calibration of burnt bone.

Methods: This paper proposes a patented prototype scale with calibrated colors of burnt bone colors at different temperatures, based on the existing RGB color published data as a visual aid in the interpretation and estimation of the maximum temperature exposure of burnt bone.

Results and Discussion: Authors are aware that the estimation of the maximum temperature of burnt bone cannot be determined solely by colors. Visual color recognition is prone to errors.

Conclusion: The proposed device should be considered a tool during photography of burnt bone and aid in interpreting temperature estimates.

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1. INTRODUCTION

Forensic pathologists, archeologists, and forensic anthropologists are often required to interpret burnt bones. One of the key factors for an accurate interpretation of the remains and the events leading to incineration is the estimation of the maximum exposure temperature of the human remains [1]. Several kinds of research focus on temperature estimation, color assessment, histology observations, and mechanical changes, which can help interpret the most accurately [2, 3].

The color of burnt bone is inevitably related to the time and temperature(s) to which it was exposed, the size and condition of the bone, and the environment. Nevertheless, it should be possible to estimate exposure temperature based on visual observation of these colors. Heated and burnt bone color changes have been analyzed by several researchers [4-6], and they vary from ivory white, to brown and black, with different shades of grey and chalky white [6, 7]. Visual assessment of human remains exposed to fire to evaluate the maximum temperature exposure is unreliable, and a solely subjective analysis in forensic casework should be avoided.

However, a colorimetric scale has never been proposed to enhance the accuracy of photographic color reproduction and photo-editing color calibration of burnt human bones.

2. MATERIALS AND METHODS

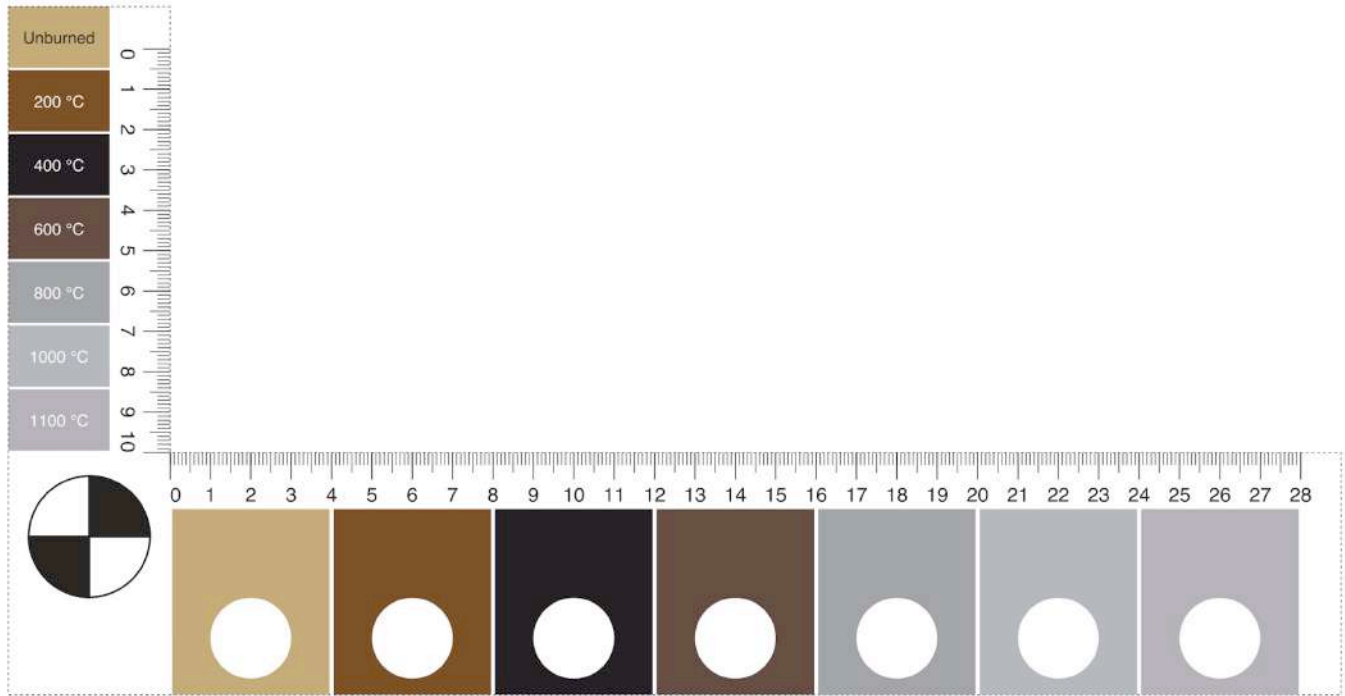
This paper proposes a patented prototype scale [8] that may be used for the forensic photography of burnt human bone exposed to different burning temperatures as an aid in the interpretation and estimation of the maximum temperature exposure of burnt bone, also allowing a reliable standard condition and the color calibration during photography. The (utility) patent of the invention belongs to the University of Turin, Italy. The scale was constructed per the existing RGB colors available through the published data [6, 7, 9, 10].

3. RESULTS AND DISCUSSION

The scale consists of an L-shaped ruler with double references, both dimensional and colorimetric. Linear references consist of a ten-centimeter scale on the short side, a twenty-eight-centimeter scale on the longer side, and one circle in the corner (diameter three centimeters, divided into black and white sectors for the black and white levels). The

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(a)



(b)

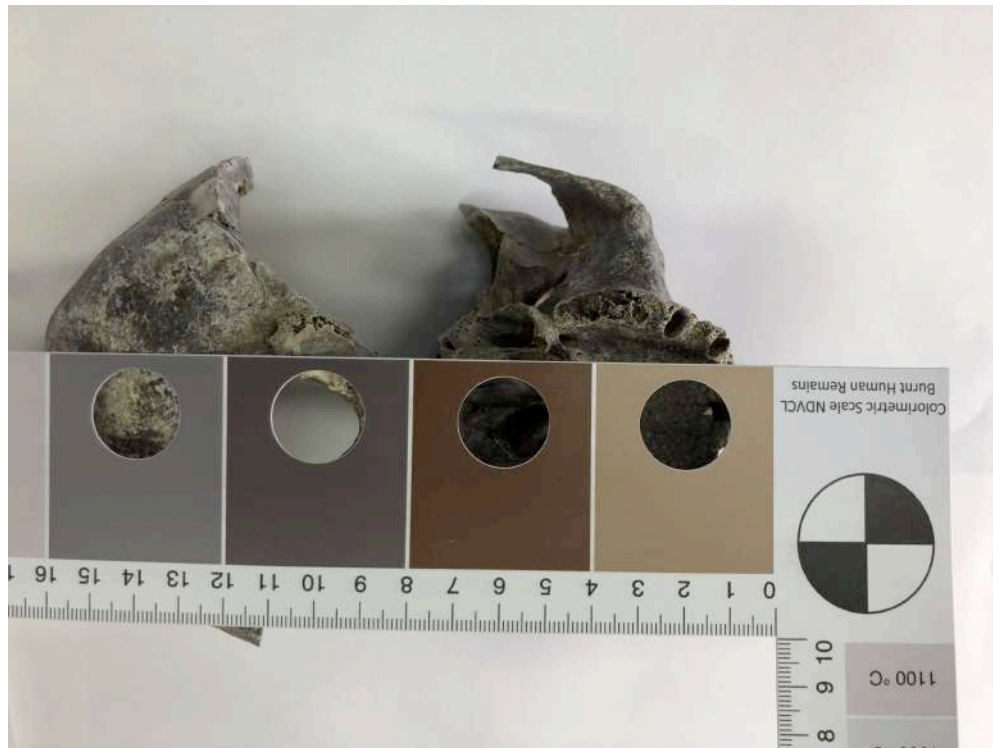


Fig. (1). The burnt bone colorimetric scale, IT utility patent n. 202021000000785, 2021. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

colorimetric references consist of seven colors pertinent to burnt bone colors at different temperatures: unburned; 200°C; 400°C; 600°C; 800°C; 1000°C; 1100°C. On the longer side, each color references have a circular aperture to find the most similar color once placed over the examining

human remains (Fig. 1). Colors have to be considered an aid in the interpretation and estimation of the maximum temperature exposure of burnt bone, allowing a reliable standard condition and the color calibration during photography.

The scale can be used during photographic documentation in combination or instead of a traditional forensic ruler.

CONCLUSION

Authors know that it is difficult to estimate the temperature range based solely on colors and that visual color recognition is prone to errors. Temperature estimation of burnt bone should not be performed only through a subjective analysis. In forensic casework, colorimetry and spectrophotometry measurements should always be preferred [11, 12]. However, no method available can objectively estimate 100% of the temperature to which human remains have been exposed during a fire.

However, while considering imprecision, subjective color analysis can still provide useful information on the degree of thermal alterations of burnt bones [10], especially for quick estimations and in the absence of other colorimetric analysis tools.

For this reason, the proposed tool should be used with caution along with other findings and observations to prevent misjudgments. The *Burnt Bone Colorimetric Scale*® should be considered an aid in the interpretation and estimation of the maximum temperature exposure of burnt bone and a tool for photographic documentation.

In order to improve the preliminary results obtained, further research is needed to validate this tool on a broad sample of burnt bone.

AUTHORS' CONTRIBUTIONS

Nuzzolese E: Conceptualization, Methodology, Validation, Writing - Original draft preparation, Supervision. **Lupariello F:** Writing - Review & Editing, Visualization. **Tattoli L:** Writing - Review & Editing. **Di Vella G:** Methodology, Validation, Supervision.

ABBREVIATION

RGB = Red, Green and Blue

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

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