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Original article

PHOTOMETRIC ANALYSIS IN DENTISTRY: A PILOT METHODOLOGICAL STUDY USING DIGITAL PHOTOGRAPHY ON ARTIFICIAL SURFACES

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ABSTRACT

Purpose: Digital photography can be utilized for photo- and colorimetric analysis of various findings in the maxillofacial region. To date, these methods are limited, expensive and complex to execute. The aim of this study is to design a simple, inexpensive, and straightforward methodology for assessing different metrics that would be beneficial for both dental science and the monitoring of the healing and treatment processes.

Material and methods: To realize this aim, 30 samples with a regular circular shape were initially prepared and used for the development of the current method. They were analyzed with specialized digital photography equipment and photographic software. Their area and perimeter were manually calculated by means of mathematical formulas. Afterwards, a digital measurement was performed on the captured image by defining the pixel count in 10 mm of the same image. The region of interest is marked, and different parameters such as area and perimeter were calculated.

Result: The results of the study indicate that the mean values for perimeter and area obtained from both measurement methods are similar, with no statistically significant differences observed between them ($p>0.05$).

Conclusions: The method for photo- and colorimetric analysis that we have developed ensures accurate measurements of parameters such as hue, chroma and value. The application of this methodology is highly beneficial in analyzing complex-shaped objects where manual measurement of the metric parameters is almost impossible. Our newly developed methodology has several advantages, such as its non-invasiveness, low-cost and easy execution, reproducibility and rapid analysis of metrical parameters.

Keywords: dental, photography, photogrammetry, digital, analysis,

INTRODUCTION

Photography has long been utilized in dental medicine. With the implementation of digital technologies, the photographic process has become more accessible and enabled a wide range of analyses, including texture, color, and photometry. Nonetheless, existing methods for photometric and colorimetric analysis remain limited, often complex and expensive [1, 2, 3, 4]. Therefore, the development of a simplified, user-friendly, and economical method for assessing metric parameters could significantly benefit scientific dental practices and improve the monitoring of healing and treatment processes.

The application of dental photography offers photometric and colorimetric analysis of various findings in the maxillofacial region. Photogrammetry is a method adopted in different fields, such as archaeology, art, and architecture. Its application in dental medicine enables accurate, rapid, and straightforward analyses that would typically require dedicated equipment, expertise, and a considerable amount of time [2, 3].

OBJECTIVE:

To develop a methodology for a precise measurement of the perimeter and area of dental surfaces using digital photography.

MATERIALS AND METHODS

Materials

1. Thirty printed samples of circles with varying sizes – perimeter and area.

2. Highly specialized digital photographic equipment:

• Canon EOS 6D Mark II camera (*Canon U.S.A., Inc.*)

• Canon EF 100mm f/2.8L Macro IS USM macro lens (*Canon U.S.A., Inc.*)

• Canon MR-14 EX II Macro Ring Lite flash (*Canon U.S.A., Inc.*)

3. Photographic software – Adobe Photoshop (*Adobe*)

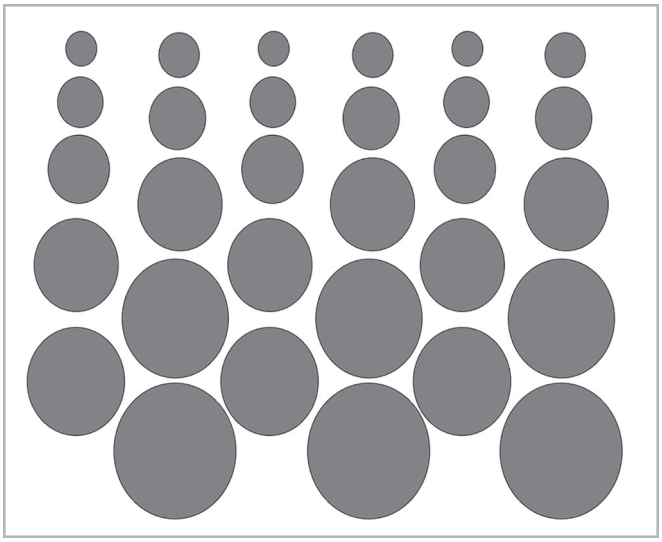
Methods

Thirty circles of varying diameters are prepared in color using Adobe Photoshop (to facilitate easier digital measurement) – Fig. 1. Their perimeter and area are determined through linear measurement and calculated using the following formulas:

- $P=\pi.d=2.\pi.r$
- $S=\pi.r^2$,

where P = perimeter; S = area; π = 3.14; d = diameter of the circle; r = radius of the circle.

Fig. 1. Pre-prepared samples for the analysis of metric characteristics.

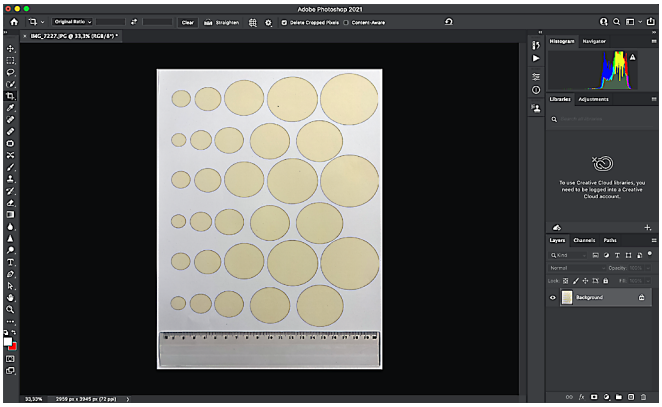


These samples are documented using a standardized photographic protocol:

1. Each sample is captured following the principle of parallelism – the camera lens is arranged perpendicular to the surface being photographed. The camera settings (shutter speed, ISO, aperture) are standardized for all images – ISO: 200; Shutter speed: 1/160; f=36. A measuring line, calibrated at 1 mm intervals, is positioned in the same plane as the sample during the photographing process.

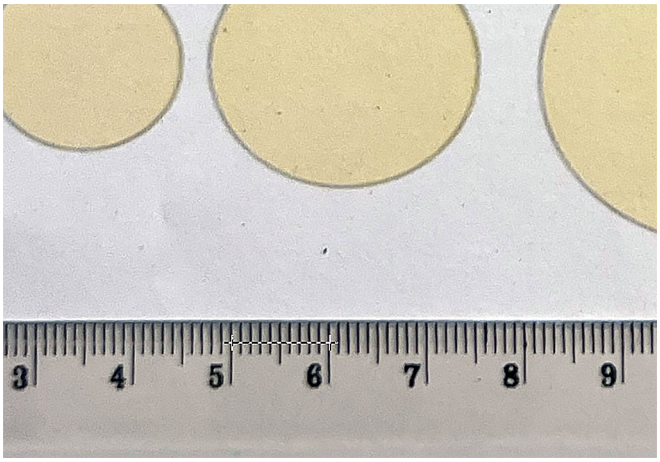
2. The captured image is imported into dobe Photoshop – fig. 2

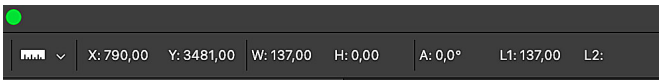
Fig. 2. Importing the photo with a scale (ruler) into Adobe Photoshop.



3. The number of pixels (X count) contained within one centimeter (10 mm) of the image is determined. To achieve this, a distance from point A to point B (the distance from 0 to 1 cm on the line) is marked using the ruler tool, which corresponds to a specific number of pixels (L1) – fig. 3.

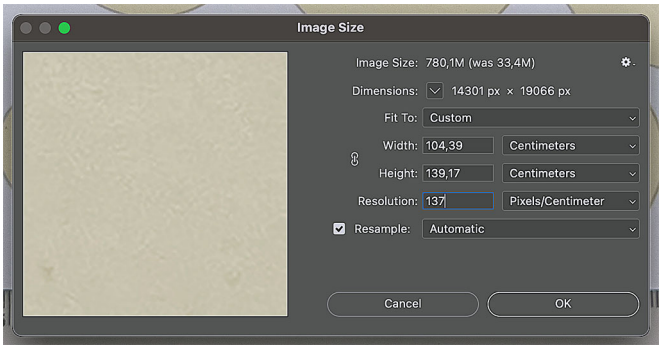
Fig. 3. Determination of the number of pixels in 10 mm: **a)** marking 10 mm on the line; **b)** checking the number of pixels in the designated segment (L1).





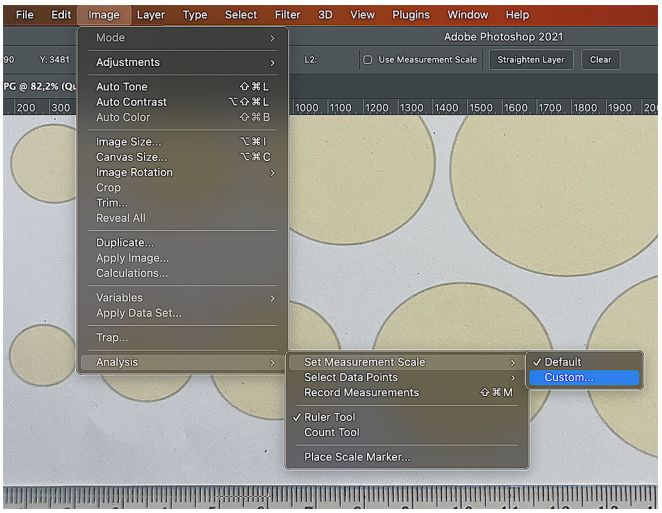
4. The resolution of the image is adjusted by setting a new value based on the measured pixels, ensuring it contains a specified number of pixels (X) per centimeter (selecting the option "number of pixels per millimeter from the image") – Fig. 4.

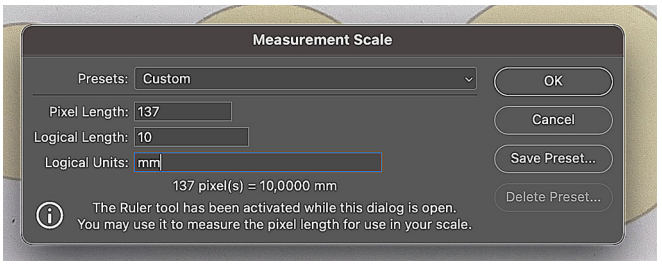
Fig. 4. Changing the resolution of the image by specifying the number of pixels per centimeter (10 mm).



5. A new scale is set for the image in millimeters or centimeters – Fig. 5.

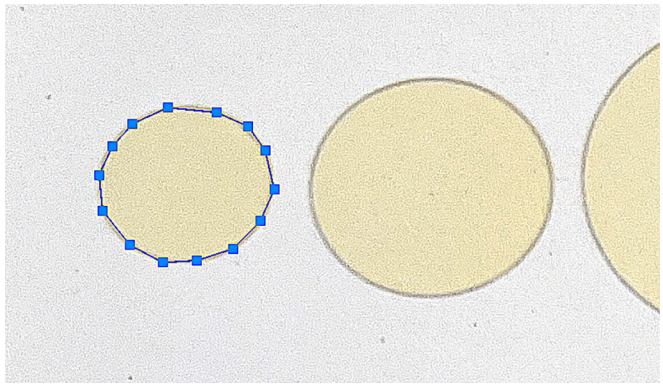
Fig. 5. Setting a measurement scale in the image (to be used with the "ruler" tool) by entering the number of pixels in 10 mm.

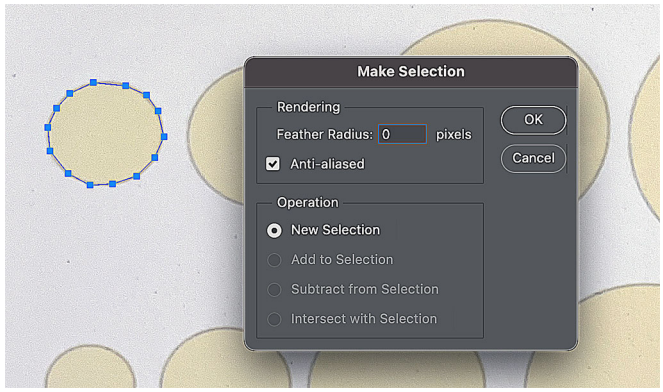




6. The area of the sample is marked in Adobe Photoshop using the selection tools (e.g., "pen tool," with the "paths" setting) – Fig. 6.

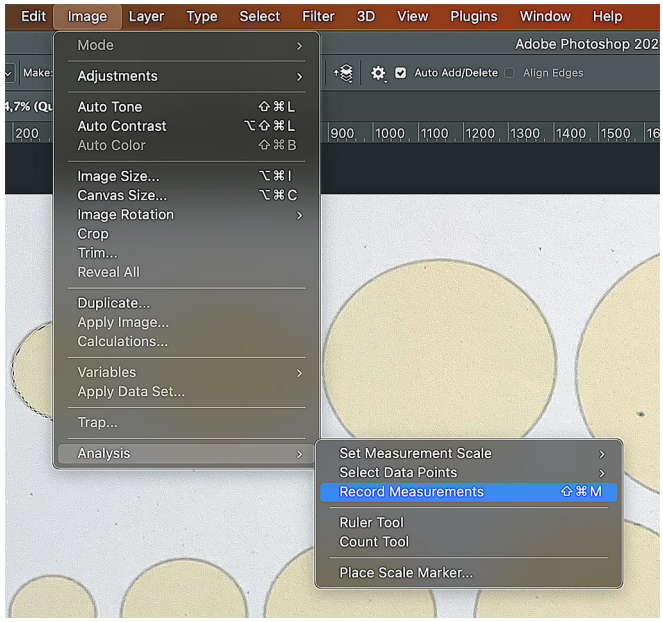
Fig. 6. Marking the area of the sample with the "pen tool" using the "paths" setting.





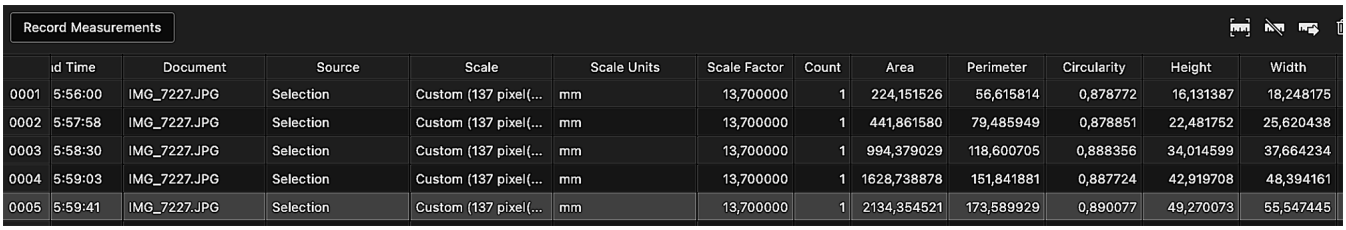
7. By using the measurement tools in Adobe Photoshop, a calculation is obtained for the actual area of the white-spot lesion based on the newly defined scale (square millimeters or centimeters). The software calculates the corresponding metric parameters for the marked pixel count.

Fig. 7. Recording of the measurements in the selected area.



8. Upon the completion of the measurements, a record is generated in the form of a text document containing the measurements taken – Fig. 8.

Fig. 8. Generation of a record of measurements for the selected area – area, perimeter, circularity, height, width, and others.



Record Measurements

	id Time	Document	Source	Scale	Scale Units	Scale Factor	Count	Area	Perimeter	Circularity	Height	Width
0001	5:56:00	IMG_7227.JPG	Selection	Custom (137 pixel(...	mm	13,700000	1	224,151526	56,615814	0,878772	16,131387	18,248175
0002	5:57:58	IMG_7227.JPG	Selection	Custom (137 pixel(...	mm	13,700000	1	441,861580	79,485949	0,878851	22,481752	25,620438
0003	5:58:30	IMG_7227.JPG	Selection	Custom (137 pixel(...	mm	13,700000	1	994,379029	118,600705	0,888356	34,014599	37,664234
0004	5:59:03	IMG_7227.JPG	Selection	Custom (137 pixel(...	mm	13,700000	1	1628,738878	151,841881	0,887724	42,919708	48,394161
0005	5:59:41	IMG_7227.JPG	Selection	Custom (137 pixel(...	mm	13,700000	1	2134,354521	173,589929	0,890077	49,270073	55,547445

The examined samples were divided into 2 groups. Group 1 (n=30) consists of the manually measured values obtained using a ruler and the corresponding formulas for perimeter and area of the samples, while Group 2 (n=30) comprises the measurements taken through the digital method. To eliminate the bias, all procedures were performed by a single operator who has expertise in the field of dental photography.

Statistical analysis

The obtained data is tabulated and further statistically analyzed by IBM SPSS Statistics 23.0 software (*International Business Machines Corporation, New York, NY, U.S.A.*). A paired samples t-test is used to compare the values distributed into two groups. The confidence level was set at ($p < 0.05$).

RESULTS

The mean values of perimeter and area of the specimens in both experimental groups are presented in Table 1. The results of the study indicate that the mean values for perimeter and area obtained from both measurement methods are similar, with no statistically significant differences observed between them ($p>0.05$).

Table 1. Mean values of perimeter and area of the pre-prepared samples were measured manually and through the digital photometric analysis.

Variable Method of measurement	Perimeter ±SD	Area ±SD
Manual (n=30)	11.5 ± 4.42	10.72 ± 7.2
Digital (n=30)	11.6 ± 4.4	11.4 ± 7.3
T-test	t=-14.365 p>0.05	t=-8.57 p>0.05

DISCUSSION

Clinical photographs enhance documentation and provide a visual record that supports comprehensive dental care.

Clinical photographs enhance documentation and provide a visual record that supports comprehensive dental care. This is particularly beneficial for diagnostics of caries lesions, gingival recession defects, monitoring of the progression of oral diseases, tooth color determination, assessment of treatment efficacy, and documentation of cases for educational or legal purposes [4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14].

With the advancement of digital technologies, the photometric analysis is likely to play a key role in remote dental appointments and monitoring. The high-resolution images can be shared with a wide range of dental specialists, thereby improving patient access to care in remote or underserved areas [9].

This pilot study aimed to assess the relevance of using digital photography and commonly available software to measure the area and perimeter of circular artificial objects. Adobe Photoshop has the capacity to calculate surface area by defining the boundaries of the region of interest and using pixel-based measurements. It is a widely recognized tool for image analysis and has been applied in various areas of dental research [15, 16, 17, 18]. Our long-term goal is to determine whether this method can be validly applied to dental surfaces, offering an accessible and cost-effective tool for metric analysis in general dental practice.

In the present study, we selected objects with regular circular shapes to eliminate potential bias in the manual evaluation of area and perimeter, as these can be calculated precisely using established mathematical formulas. Nevertheless, the use of artificial surfaces may not capture the anatomical complexity of enamel or periodontal tissues. Given the preliminary nature of this study, the findings should not be directly applied to clinical practice without further validation. Future research is already

planned to assess the method's applicability in monitoring in vitro and in vivo changes in dental structures and tissues with irregular shapes.

Certain limitations of the current study should be considered. The lack of standardized lighting could affect accuracy, and the limited sample size may constrain generalizability.

Our results showed no significant difference between the manual and digital measurement approaches tested, suggesting a reliable performance using minimal technical setup. This is encouraging, especially given the use of basic digital photography—tools already available to most dental professionals.

CONCLUSION

The digital method for photometric analysis of the perimeter and area of objects with a regular circular shape is precise, repeatable and relatively easy to implement. The results support the potential utility of simple digital photography and mainstream software as an accessible tool for metric analysis. While these results are preliminary, they lay the groundwork for further validation aimed at practical clinical adoption.

PATENTS

The method is currently in the process of being patented and is protected under intellectual property rights.

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