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EFFECT OF PHOTOGRAPH-CAPTURING DEVICES ON THE ANTHROPOMETRIC ANALYSIS OF MAXILLARY INCISOR DISPLAY

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Abstract: Effect of Photograph-Capturing Devices on The Anthropometric Analysis of Maxillary Incisor Display. *An aesthetic smile enhances a person's attractiveness and has a positive impact on psychosocial health. The maxillary incisor display takes an important role in achieving an aesthetic smile. Therefore, dentists must ensure that their treatments do not interfere with the appearance of these teeth. Anthropometric analysis of maxillary incisor display is generally performed using profile photographs while smiling, taken with a digital camera. However, due to the limitation of face-to-face interactions imposed by the COVID-19 pandemic, alternative methods for data collection were required to facilitate anthropometric analysis. This study aimed to determine if there are differences in the measurement results of maxillary incisor displays when smiling through a profile photograph captured with a digital camera versus a webcam. This analytical observational study had a cross-sectional design and involved 110 participants who met the inclusion criteria. Profile photographs were captured with both a digital camera and a webcam. The maxillary incisor display was measured from both sets of profile photographs using CorelDraw Graphic Suite 2022 and was further analysed using the Chi-square test. The measurements of maxillary incisor display obtained from a digital camera and a webcam showed agreement in 67.3% of participants, whereas 32.7% were classified in different smile categories. Overall, the measurements obtained from two devices differed significantly (p = 0.003). Using a digital camera and webcam to take profile photos produced significantly different anthropometric measurements, suggesting that digital cameras should be preferred for standardized smile analysis.*
Keywords : *Smile Anthropometry, Maxillary Incisor Display, Digital Camera, Webcam Smile.*

Abstrak: Pengaruh Perangkat Pengambilan Foto terhadap Analisis Antropometri Tampilan Gigi Insisivus Maksila. Senyum estetis meningkatkan daya tarik seseorang dan memiliki dampak positif pada kesehatan psikososial. Tampilan gigi insisivus maksilaris berperan memberikan tampilan senyum yang estetis. Oleh karena itu, dokter gigi harus memastikan perawatan yang mereka berikan, tidak mengganggu penampilan gigi ini. Analisis antropometrik tampilan gigi insisivus maksilaris umumnya dilakukan menggunakan foto profil saat tersenyum, yang diambil dengan kamera digital. Namun, akibat pembatasan interaksi tatap muka akibat pandemi COVID-19, metode alternatif pengumpulan data diperlukan, untuk melakukan analisis antropometri. Penelitian ini bertujuan untuk menilai apakah terdapat perbedaan dalam hasil pengukuran tampilan gigi insisivus maksilaris saat tersenyum melalui foto profil yang diambil dengan kamera digital dibandingkan dengan kamera web. Studi observasional analitik ini memiliki desain potong-silang dan melibatkan 110 partisipan yang memenuhi kriteria inklusi. Foto profil diambil

menggunakan kamera digital dan kamera web. Tampilan gigi insisivus maksilaris pada kedua set foto profil diukur menggunakan CorelDraw Graphic Suite 2022 dan dianalisis dengan Uji Chi-square. Pengukuran tampilan gigi insisivus maksilaris dari kamera digital dan kamera web menunjukkan kesesuaian hasil pada 67,3% partisipan. Namun, kedua perangkat menunjukkan perbedaan hasil pada 32,7% partisipan. Terdapat perbedaan signifikan antar hasil pengukuran dari kedua perangkat (p= 0,003). Penggunaan kamera digital dan kamera web dalam pengambilan foto profil menghasilkan perbedaan yang signifikan pada hasil pengukuran antropometri. Berdasarkan temuan tersebut, penggunaan kamera digital disarankan untuk analisis senyum yang terstandar.

Kata Kunci : Antropometri Senyum, Tampilan Gigi Insisivus Maksilaris, Kamera Digital, Kamera Web, Senyum.

INTRODUCTION

Facial expressions play a role in interpersonal interactions by conveying emotions and shaping social perceptions of a person's personality. Those showing positive emotions tend to receive positive feedback in nonverbal communication (Alexandra et al., 2023; Horn et al., 2021). Smiling is an expression that conveys happiness, joy, friendliness, and excitement (Alexandra et al., 2023; Anggraini et al., 2020; Horn et al., 2021; Manjula et al., 2015). An attractive smile can strengthen interpersonal relationships. It can also help an individual gain acceptance in society (Anggraini et al., 2024; Ariyani et al., 2024; Bahirrah & Sitorus, 2015).

The muscles of facial expression surrounding the mouth play an important role in forming a pleasing smile. The *m. zygomaticus major* acts to lift the mouth corners superiorly and laterally and to curve the upper lip, which then produces a smile. Contraction of *m. levator labii superioris* also contributes to lifting the upper lip and forming the *sulcus nasolabialis*. The *m. zygomaticus minor* and *m. levator anguli oris* are involved in lifting the upper lip and mouth corners, as well as deepening the *sulcus nasolabialis*. The *m. levator anguli oris* cooperates with *m. zygomaticus major* to widely open the *rima oris*, exposing the anterior maxillary teeth. Meanwhile, contraction of the *m. orbicularis oculi* forms wrinkles at the lateral corners of the eyes, giving the smile an impression of sincerity (Abdurachman, 2018; Anggraini et al., 2020, 2024; Ariyani et al., 2024; Manjula et al., 2015). *M. risorius*, *m. levator labii superioris alaque nasi*, and *m. buccinator* are the other muscles of facial expression that also contribute to forming a smile (Abdurachman, 2018; Alexandra et al., 2023; Anggraini et al., 2024; Ariyani et al., 2023; Baker, 2016).

In interpersonal interactions, it's undeniable that the face is the focal point of attention (Aldegheishem et al., 2024; Alexandra et al., 2023), and the mouth and teeth play an important role in supporting aesthetics (Saini et al., 2022). An attractive smile enhances a person's appearance and contributes to their psychosocial health (Aldegheishem et al., 2024; Alexandra et al., 2023; Anggraini et al., 2024). In modern dental practice, dentists must complement their technical skills with an understanding of aesthetic standards for smiles to ensure their treatments may support patients' appearances (Anggraini et al., 2024; Ariyani et al., 2024; Farid et al., 2025). The components assessed in smile aesthetics include the shape of the lip line, the smile arc, the upper lip curvature, the buccal corridor width, the smile symmetry, the maxillary incisor display, and the appearance of the gingiva, as well as the proportion and colour of the teeth (Abdurachman, 2018; Anggraini et al., 2020, 2024; Ariyani et al., 2024; Farid et al., 2025; Manjula et al., 2015).

Digital photography is commonly used as an indirect anthropometric method (Kashmoola et al., 2020), for evaluating smile components (Ramaswamy et al., 2021; Schabel et al., 2010). A study has shown that data collected using 2D photography is just as accurate as data collected using direct anthropometric methods (Kashmoola et

al., 2020). Photography is also widely used in medical practice for treatment planning, evaluating treatment progress, documentation, communication, and legal purposes (Moussa et al., 2021). For the aesthetic treatment plan, it is recommended that the dentist collect profile photographs, including images of the patient smiling as widely as possible from front, right, and left lateral views, as well as images of the lips in a relaxed position (Schabel et al., 2010).

The advantages of digital photography became increasingly apparent during the COVID-19 pandemic (Moussa et al., 2021), when social activities transformed into virtual interaction (Bratan et al., 2021; Moussa et al., 2021) to prevent the transmission of the SARS-CoV-2 virus (Omary et al., 2020). Lockdown policies and distant socializing during the pandemic caused various studies, including in-vitro, in-vivo, clinical, and public health studies, to be delayed or even halted (Bratan et al., 2021; Harper et al., 2020; Omary et al., 2020; Pandi-Perumal et al., 2021; Sohrabi et al., 2021). The challenges arising from the pandemic's negative impact on scientific research included difficulties in recruiting participants, delays in collecting data, and limited access to research facilities (Bratan et al., 2021; Harper et al., 2020; Sohrabi et al., 2021).

The COVID-19 pandemic has brought significant changes in various aspects of society, particularly in academia and research (Harper et al., 2020). This situation highlighted the need for alternative methods of collecting facial profile data, including the use of webcams, which would facilitate remote data collection, reach participants across wider areas, and be less affected by lockdown and distant socializing policies. Various photography devices have been used for facial anthropometric analysis (Lim et al., 2022; Moussa et al., 2021). However, evidence regarding the comparability of smile anthropometric measurements obtained using a digital camera and a webcam remains limited. Additionally, it remains unclear whether a webcam provides measurement of maxillary incisor display comparable to that obtained using a digital camera. Therefore, the present study investigated whether the use of different image-capturing devices, a digital camera and a webcam, results in differences in the measurement of maxillary incisor display during smiling.

METHODS

An analytical observational study with a cross-sectional design was conducted from September to December 2023 at the Laboratory of the Faculty of Dentistry, Universitas Trisakti. A total of 110 participants aged 17–24 years met the inclusion criteria of having complete anterior teeth in the upper and lower jaws on both sides (right and left) and healthy periodontal tissue.

Those with a history of trauma or disease causing facial deformities or muscle activity disorders, those who regularly consume corticosteroid drugs, those with a history of or currently undergoing orthodontic treatment, those with fillings in the upper anterior teeth, those with a history of or currently undergoing cosmetic treatments such as Botox injections or lip fillers, and, specifically for male participants, those with a mustache that could potentially interfere with the measurement of variables were excluded from this study. After signing the informed consent form, participants were informed about the research procedure. The Ethics Committee of the Faculty of Dentistry at Trisakti University approved the entire research procedure (number 021/S3/KEPK/FKG/6/2022).

Profile Photograph Acquisition

All participants' profile photographs were captured twice while smiling. One set of photographs was taken with a digital camera (Canon EOS 600D; 18-megapixel resolution; ISO 100–6400; 18–135 mm lens), and the other set was taken with a webcam (MacBook Air M2 2022, equipped with a 1080p FaceTime HD camera). The digital camera was mounted on a tripod, whereas the webcam was placed on an adjustable-height table. Both cameras were positioned 30 cm in front of each

participant, and all photographs were captured by the same operator. The procedure for capturing profile photographs followed the protocol described in our previous study (Anggraini et al., 2024; Ariyani et al., 2024).

The reference area for capturing the profile photograph included the forehead, the inferior border of the chin, and both ears. Participants were required to remove any makeup prior to the photograph's acquisition. During the procedure, participants were seated upright and instructed to look straight ahead at an imaginary point on the wall at eye level to achieve a neutral head position (NHP). To maintain the NHP, participants wore glasses equipped with a spirit level.

Participants were further instructed to say "cheese" to produce a social smile and to smile as widely as possible, ensuring that the cervico-incisal length of the maxillary central incisors was clearly visible. A 20 x 30 cm elbow ruler was placed on the right side of the participant's head, parallel to the head, to serve as a reference for further measurements during profile photographs acquisition. The ruler was also equipped with a spirit level.

Measurement of Profile Photograph

The maxillary incisors display in smiling profile photographs captured with the digital camera and the webcam were measured using the parallel dimension tool in CorelDraw Graphic Suite 2022. Anthropometric analysis of the smile components was performed independently by two healthy and emotionally stable assessors. The maxillary incisor display was calculated by dividing the visible crown length of the maxillary central incisor (measured from the incisal edge to the inferior border of the upper lip while smiling) by the actual cervico-incisal crown length. The measurement results were presented in percentages and classified into three categories: high, average, and low smiles (Ariyani et al., 2023, 2024; Bahirrah & Sitorus, 2015). A high smile was defined as exposing the full length of the cervico-incisal of the maxillary central incisor while smiling, with some of the gingival margin visible. An average smile was defined as exposing 75–100% of the cervico-incisal length of the maxillary central incisor and the interdental papilla. Whereas, a low smile was defined as an exposure of less than 75% of the cervico-incisal length of the maxillary central incisor.

Statistical Analysis

The Chi-square tets was performed to determine the differences in the anthropometric measurements of the maxillary incisors display between two sets of profile photographs captured with a digital camera and a webcam. A significance value of $p<0.05$ was applied.

RESULTS

The present study involved 110 participants who met the inclusion criteria. A total of 220 smiling profile photographs were divided into two groups: those captured with a digital camera (n=110) and those captured with a webcam (n=110). All profile photographs were obtained from the same participants, and those photographs were then measured using a 20x30 cm ruler as a reference.

Inter-rater Reliability

Two calibrated assessors measured the maxillary incisor display. Cohen’s kappa test was used to assess inter-rater reliability. The results showed that the kappa value for measuring the maxillary incisor display from the digital camera group was 0.831, and from the webcam group, 0.866 (Table 1). These results indicate that the level of agreement between assessors was very good.

Table 1. Inter-rater Reliability

	Photograph Capture Device	*Kappa* value	Power of Agreement
Maxillary Incisor Display	Digital Camera	0.831	Very good
	Webcam	0.866	Very good

Maxillary Incisor Display

This study found that 74 participants (67.3%) had the same smile category when captured by both capture devices, the digital camera and the webcam, based on the maxillary incisor display. Among these participants, 51 participants (46.4%) exhibited a low smile, 22 participants (20%) had a medium smile, and one participant (0.9%) had a high smile. In contrast, 36 participants (32.7%) had different smile categories between the two devices. Statistical analysis revealed a significant difference in the maxillary incisor display measurement obtained from the digital camera and the webcam (p=0.003, p<0.05) (Figure 1; Table 2).

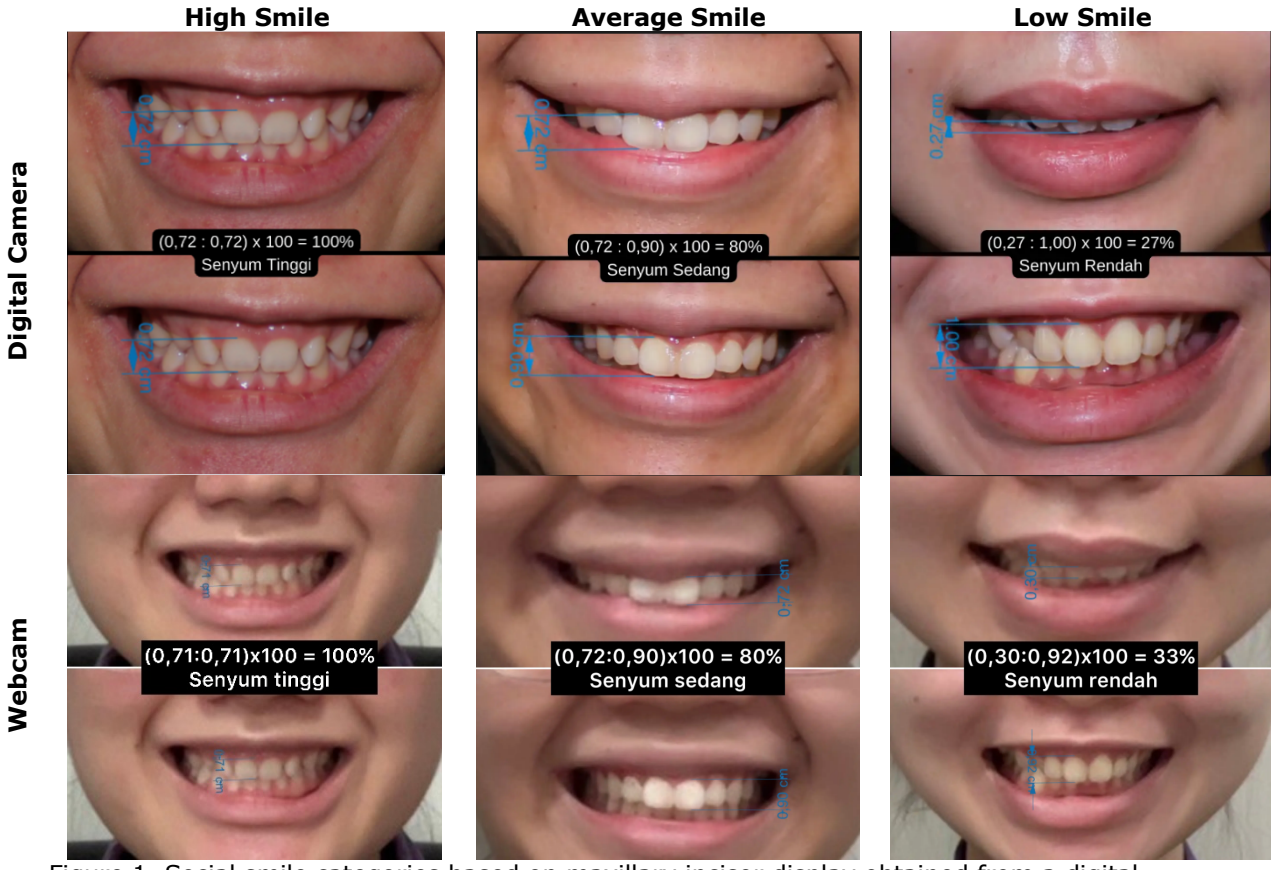

Figure 1. Social smile categories based on maxillary incisor display obtained from a digital camera and a webcam.

Table 2. Anthropometric analysis of maxillary incisor display obtained from digital camera and webcam images.

		Digital Camera			
		High smile	Average	Low Smile	*p*
		n (%)	n (%)	n (%)	
Webcam	High smile	**1 (0.9%)**	3 (2.7%)	3 (2.7%)	
	Average smile	0 (0%)	**22 (20%)**	23 (20.9%)	0.003*
	Low smile	1 (0.9%)	6 (5.5%)	**51 (46.4%)**	
	Jumlah	77 (70%)	31 (28.2%)	2 (1.8%)	

*Chi-square test, $p<0.05$

DISCUSSION

The maxillary incisor display while smiling positively influences the aesthetic value of a smile (Ariyani et al., 2023, 2024; Zaini et al., 2013). This smile component is defined as the cervico-incisal length of the maxillary central incisor exposed when the mouth is at rest or in function (Ariyani et al., 2023, 2024). An average smile exhibiting 75% of the maxillary incisors while smiling is considered aesthetically pleasing (Ariyani et al., 2023; Bahirrah & Sitorus, 2015). Photographic images have also been commonly used to evaluate smile components (Kashmoola et al., 2020; Ramaswamy et al., 2021; Schabel et al., 2010), including maxillary incisor display (Ariyani et al., 2024).

During the COVID-19 pandemic, lockdown policies and distant socializing hindered the data collection of profile photographs (Bratan et al., 2021; Harper et al., 2020). To address this issue, a webcam was used as an alternative method for obtaining anthropometric data. Therefore, the present study aimed to determine whether differences exist in maxillary incisor display measurements obtained using a digital camera and a webcam.

A total of 220 smiling profile photographs were captured using a digital camera and a webcam. The maxillary incisor display in both sets of photographs was measured independently by two calibrated assessors using CorelDraw Graphic Suite 2022. The inter-rater reliability was first assessed to determine the agreement level between the two assessors for each photograph acquisition device group. The Kappa coefficient value was 0.831 for the digital camera group and 0.866 for the webcam group, indicating very good inter-rater agreement. These results demonstrated that the measurements were reliable and consistent.

Crosstabulation analysis and Chi-square test were performed to determine the differences in maxillary incisor display measurements obtained using two photography acquisition devices: a digital camera and a webcam. The results showed a significant difference between the two devices, with a *p*-value of 0.003 ($p<0.05$). Most participants (67.3%) had consistent smile categories across both sets of photographs, with low smile (46.4%) being the common expression, followed by average smile (20%), and high smile (0.9%). In contrast, 32.7% of participants had different smile categories between the two devices.

Maxillary incisor display represents a relatively small vertical distance determined by the relationship between the inferior border of the upper lip and the visible portion of the maxillary incisors (Ariyani et al., 2024). The agreement observed in 67.3% of participants indicated that the digital camera and the webcam captured the same anatomical landmark of maxillary incisor display. However, disagreement was also observed in 32.7% of the remaining participants, indicating that the two devices may not be directly interchangeable for standardized smile analysis. These findings suggested that device selection for taking profile photographs might influence the visibility of anatomical landmarks on the

maxillary incisor display measurements.

Two-dimensional (2D) photography is commonly used as an alternative method for indirect anthropometry (Kashmoola et al., 2020). Indirect anthropometric methods offer greater convenience, time efficiency, and ease of data collection compared with direct anthropometry instruments such as calipers, stadiometers, scales, or weighing scales. These advantages are particularly beneficial for participants who are unable to stand or sit for extended periods (Kashmoola et al., 2020; Mocini et al., 2023). Although RGB cameras (including webcams, cell phone cameras, and digital cameras) (McDuff, 2023) can produce clear and sharp images (McDuff, 2023; Xie & Yang, 2020), visual clarity alone does not guarantee image accuracy or reliably identify anatomical landmarks. Therefore, image-capturing devices should be standardized before being applied to anthropometric analysis.

Our findings demonstrated that the use of a digital camera versus a webcam might affect the results of the anthropometric analysis of the maxillary incisor display. Image resolution (Kashmoola et al., 2020) and distortion (Kashmoola et al., 2020; Lee et al., 2014) affected photo accuracy. Image distortion is primarily related to the distance between the camera and the subject. A previous study (Třebický et al., 2016) has also stated that focal length affects image magnification and field of view. The interaction between focal lengths and camera-to-subject distance may alter how facial proportion is represented in profile photographs. Profile photographs captured with shorter focal lengths, which are typically taken at a closer distance between the subject and the camera, may produce the central facial proportion appearing more prominent and the face appearing more rounded. Whereas profile photographs captured with longer focal lengths, which are typically taken at a greater distance, may produce a flatter facial appearance (Třebický et al., 2016).

In medical and dental photography, the use of a camera with a minimum resolution of 5 megapixels and lenses with a range of 90 – 105 mm is recommended, as these specifications help to reduce distortion and enhance image resolution, providing detailed capture of facial anatomy (Kashmoola et al., 2020; Swamy & Most, 2010). In addition, maintaining an appropriate and standardized distance between the camera to subject is important to minimize distortion and ensure consistent image magnification (Kashmoola et al., 2020). DSLR cameras allow users to manually adjust the lens aperture and exposure time (Moussa et al., 2021; Swamy & Most, 2010), providing greater control over image quality. In contrast, webcams commonly rely on automatic image adjustments and processing, which facilitate image acquisition (Moussa et al., 2021; Slim et al., 2024).

A previous study on facial anthropometry comparing DSLR cameras with direct measurement using calipers has shown that DSLRs can generate the same measurement accuracy as calipers when appropriate lens aperture settings and camera-to-subject distances were applied (Kashmoola et al., 2020). Another study that compared DSLRs and smartphone cameras reported no significant difference in the measurement of curvature and cervico-incisal length of the maxillary anterior teeth obtained using the two devices (Moussa et al., 2021). The main difference between the two studies lies in the ideal distance between the camera and the subject. The first study suggested an optimal distance of two meters to provide good measurement accuracy (Kashmoola et al., 2020). Whereas the second study suggested distances of 24–32 cm for DSLR cameras and 24 cm for smartphone cameras (Moussa et al., 2021). Differences in lens characteristics, focal length, and camera-to-subject distance may also have contributed to facial image distortion, thereby influencing facial

landmark detection in facial images (Derakhshan et al., 2024).

Two-dimensional (2D) photography can be considered an alternative method in indirect anthropometry. Standardization of the equipment, along with adjustment to lighting, distance, and subject position, is necessary to achieve an optimal photographic quality (Swamy & Most, 2010). Further studies should consider a wider age range of participants to better represent social smile patterns based on the maxillary incisor displays.

The present study did not specifically evaluate the technical factors that may have affected the differences in smile categories in maxillary incisor display between two devices, such as focal length, camera-to-subject distance, and webcam image processing. Therefore, future studies should include participants from a wider age range and standardize the camera setting, focal length, and participant positioning.

CONCLUSION

The selection of photograph capture devices for taking profile photos can affect the results of an anthropometric analysis of the maxillary incisor display while smiling. Therefore, it is important to consider the right camera device for research that uses anthropometric analysis to assess the aesthetic aspects of a smile.

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