BRIEF RESEARCH COMMUNICATION

Protocol for the Use of Stereophotogrammetry Three-dimensional System in Children during the First Years of Life

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Abstract

Aims and background: To describe the protocol for the use of portable stereophotogrammetry equipment for the acquisition of three-dimensional (3D) facial images in children during the first years of life.

Materials and methods: The images were acquired using a portable stereophotogrammetry equipment (Vectra H2®). Three consecutive images were captured, starting on the right, front, and left sides of the child participant. One operator took three facial images, while another operator attracted the child's attention with a toy/children's video. After the facial captures, the software rendered the three images automatically or manually.

Results: Initially, 52 3D photographs of the participants were taken, 14 of them of children without craniofacial anomalies and 38 of children with craniofacial anomalies. The children's age ranged from 22 days to 27 months.

Conclusion: The protocol for the use of portable stereophotogrammetry equipment in children during the first years of life helps the professional in the proper positioning and management for the acquisition of 3D facial images, in addition to allowing standardization both for future studies and for use during clinical care.

Clinical significance: Knowledge about the craniofacial development of children in early childhood is critical for diagnosis and clinical practice throughout childhood growth.

Keywords: Face, Imaging, Infant, Photogrammetry, Three-dimensional.

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Introduction

Knowledge about the craniofacial development of children in early childhood is critical for diagnosis and clinical practice throughout childhood growth. Understanding craniofacial changes at various age intervals is essential to plan timely treatment of any malformations, growth arrest, and deformities.[1] However, accurate and reproducible measurements in younger children with and without craniofacial anomalies, such as cleft lip and palate, still pose a challenge due to the head stabilization problem.[2]

In this search for understanding and monitoring of craniofacial aspects, three-dimensional (3D) facial imaging systems are useful tools that allow facial evaluation, which has been gradually replacing two-dimensional (2D) systems and traditional anthropometry, which was performed through direct measurements with calipers.[3] The 3D technique is fast, noninvasive, and easily repeatable.[4] In addition, its precision and accuracy have been demonstrated and confirmed in several studies.[3,5–7] Another advantage of facial scans is that they are a powerful method for capturing various information from extraoral images, as well as allowing integration into the digital stream.[8]

The use of 3D technology in individuals with cleft lip and palate is increasingly present in recent studies in the literature. However, most studies using 3D anthropometric analyses have been conducted in children over 3 years of age due to complications during 3D scanning of younger children.[9] This is due to the challenges of lack of cooperation, movement of the child, or excessive facial emotions, causing the inability to capture neutral facial expressions, so it is typically used under general anesthesia.[10]

Since there is no protocol for the use of portable stereophotogrammetry in children during the first years of life without the use of sedation or general anesthesia, this study aimed to describe the protocol for the use of portable stereophotogrammetry equipment for the acquisition of 3D facial images in children during the first years of life.

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Conflict of interest: None

Materials and Methods

This study was submitted and approved by the Institutional Review Board (protocols 71333223.1.0000.5417 and 71333223.1.3001.5441). The legal guardians of the participants were previously informed about the study and invited to participate. After acceptance, they signed a Free and Clarified Consent Form. Children with and without cleft lip and palate during the first years of life were selected.

Subjects

Inclusion criteria comprised children aged up to 36 months, regardless of sex. Exclusion criteria were children crying and/or very agitated, and the legal guardian's refusal to participate.

3D Image Acquisition

The device used was a portable stereophotogrammetry equipment (Vectra H2®, Canfield Scientific, Parsippany, New Jersey, USA). This system consists of an 18-megapixel digital camera with two projected red-light modules that aid in positioning. In addition, the equipment has a built-in modular flash with an image capture time of 2 ms.

During the capture of the images, the portable device was connected to a notebook *via* cable so that the transmission of images between the equipment and the computer occurred in real time. To capture facial images following the Vectra H2® User Guide, the individual must stand on the positioning mat with their feet covering the red marks. However, there is no guidance regarding infants in the first year of life. All images were taken in a quiet room with artificial light. Following the manufacturer's instructions, the sequence for obtaining facial images should be from right to left of the individual.

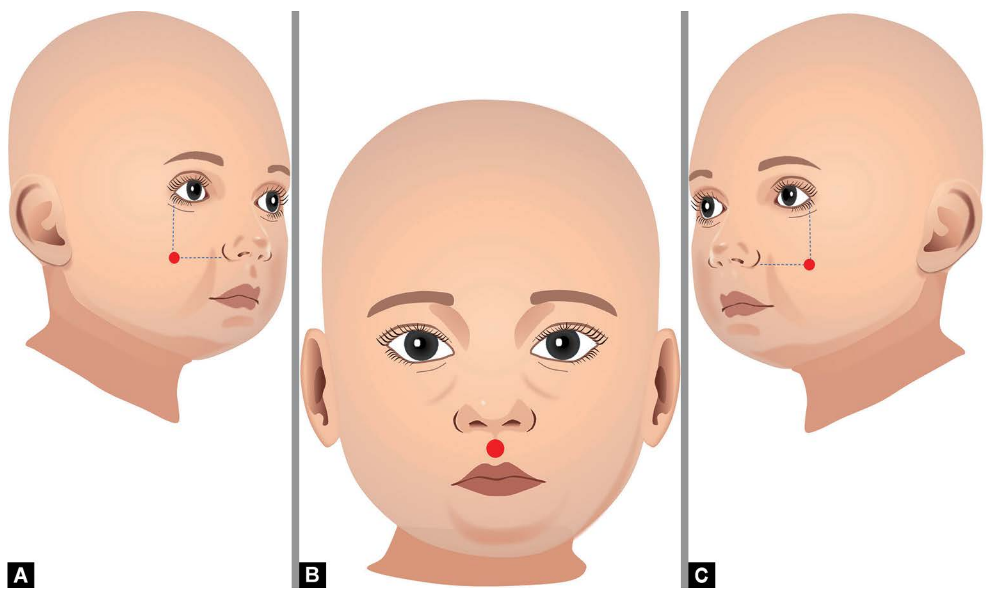
For children, the same point will be followed. The first image should be taken with the camera at a 45º angle, and the focal point of the camera should be positioned at the perpendicular line of the nasal base and exocanthus on the right side of the participant (child). The second image should be taken with the camera at a 90º angle, and the focal point of the camera should be positioned on the individual's lip filter. Finally, the third image is taken with the camera at a 45º angle, and the focal point of the camera should be positioned at the perpendicular line of the nasal base and exocanthus on the left side of the participant (Fig. 1).

During the capture of the images, the children should remain seated, calm, and awake on the lap of the legal guardians/parents, with the torso facing forward, looking at the first operator, who should attract the child's attention by either using a noisy toy or a video during the three image captures.[11] Meanwhile, a second operator should make the images according to the order (from right to left of the participant) with the same angles recommended by the manufacturer and described above (Fig. 2). It is important to wait for the moment when the child has her/his eyes open and stares at the object to make the capture. The total time of the three captures was less than 5 minutes.

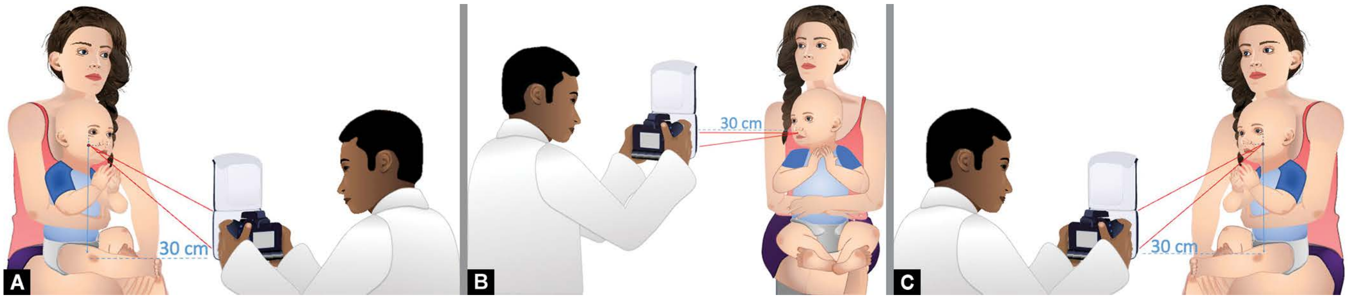
After the facial captures, the software could perform the rendering, that is, the grouping (or even the stitching) of the three images automatically or manually. When automatic, the software itself performs the rendering. However, in manual rendering, the operator should indicate the craniometric points requested by the system on each image. In the first image, the following points should be marked, in this order: right pupil, glabella, and tip of the nose; in the second image, the points marked were right and left pupils, glabella, and tip of the nose; and in the third image, the left pupil, glabella, and tip of the nose. After this step, the operator requested the system to rerender the 3D images. After the grouping was completed, all 3D images were saved in the system in the triangulate object model format (.tom).

Results

The initial sample consisted of 52 children with and without craniofacial anomalies aged between 22 days and 27 months. In children without craniofacial anomalies, 14 photographs were taken. Of these, 10 children were females and 4 were males. Of the total scans performed for this group, 9 children were rendered



Figs 1A to C: Location of the camera focal point. (A) Focal point of the camera positioned at the intersection of the line perpendicular to the right nasal base with the perpendicular line of the exocanthus on the right side of the participant; (B) Focal point of the camera positioned in the center of the lip filter; (C) Focal point of the camera positioned at the intersection of the line perpendicular to the left nasal base with the perpendicular line of the exocanthus on the participant's left side



Figs 2A to C: Participant's positioning—participant sitting on the guardian's lap, with a relaxed posture, eyes open, and torso facing forward. The first operator was always positioned in front of the participant. (A) In the first position, the camera is positioned on the right side of the participant, with 30 cm from their face, forming a 45° inclination; (B) The operator with the camera parallel to the ground positions him/herself in front of the participant, keeping 30 cm away from his/her face; (C) In the third position, the camera is positioned on the left side of the participant, with 30 cm from the face, forming a 45° inclination

Table 1: 3D facial photographs of child participants

Variables	*Children without craniofacial anomalies (n)*	*Children with craniofacial anomalies (n)*	*Total (n)*
Initial sample	14	38	52
Females	10	13	23
Males	4	25	29
Manual rendering	9	36	45
Automatic rendering	5	2	7
Excluded participants	0	3	3
Final sample	14	35	49

manually, while 5 were performed automatically. No participant was excluded from this sample set (Table 1).

For children with craniofacial anomalies, 38 3D photographs were taken. Of these, 13 were female and 25 were male. Of the total scans performed for this group, 36 children were rendered manually, while 2 were performed automatically. A total of 13 children had unilateral cleft lip, 1 had bilateral cleft lip, 12 had unilateral cleft lip and palate, 3 had bilateral cleft lip and palate, and 9 had isolated cleft palate. However, in this same group, three participants were excluded due to the intense movement of the children; even after the attempt of manual rendering, the 3D facial photograph was not obtained. Thus, the final sample obtained from both groups was 49 participants (Table 1).

Discussion

Three-dimensional technology is an important innovation for many health professionals, from the initial diagnosis to treatment follow-up. With the recent development of portable 3D cameras, the use of stereophotogrammetry in the clinic has increased due to reduced costs and increased mobility.[12] Stereophotogrammetry offers greater information value than conventional 2D photography, as it allows the quantification and localization of deviations from normal facial development at an early age.[13] Although photogrammetry is particularly useful in performing indirect anthropometry in young children, who may not be able to cooperate with direct measurements, there are few data on its usefulness and reference values.[14] However, there are numerous possible clinical applications to analyze children's facial anthropometry, such as the evaluation of facial symmetry, the relationship between the thirds of the face, the pre- and postsurgical comparison, and the monitoring of facial growth.[13,15,16] For this, it is possible to use 3D resources such as image overlay, analysis of linear and angular measurements, and volume, among others.[17–19] Thus, this study is the first to present a protocol for capturing nonionizing and noninvasive 3D facial images by using a portable device in children with and without craniofacial anomalies who are not sedated. This protocol could be applied since the first stages of life by the Pediatric Dentist, either in the hospital or in the office.

This study was carried out based on the need to define a 3D facial imaging protocol, since the portable equipment of the stereophotogrammetry system did not have guidelines on how to perform the images during the first years of life. Thus, to capture the images, the operator was previously trained and calibrated to later perform the facial images on the infant participants. It was defined that the children should be calm and not crying during the acquisition of facial images to avoid misunderstandings during the capture of the images. A previously published study[20] investigated the influence of involuntary facial expressions, by means of a fixed stereophotogrammetry equipment, in children up to 18 months of age. The authors concluded that the variation due to movement was low (1 mm) in children with and without craniofacial anomalies, both for the face and for the nasolabial area, which is clinically acceptable. Thus, it is possible to acquire nonionizing 3D facial images of children, if there are experienced photographers and a meticulous protocol of capturing images of the face is followed.[13] Another important criterion is that the images were acquired in a room with artificial light because if the ambient light was too bright or dark, it would overload the camera's sensors.[11] Moreover, the room space was also another considerable factor. The room must hold all the stereophotogrammetry systems, the operators, the adult with the child, the necessary seat, and space for the operator to move freely during the capture process.[11]

The present study showed that in the stitching of the three 3D images, in children without craniofacial anomalies, 9 presented manual rendering, while in children with craniofacial anomalies, there were 36. The rationale behind the fact of many manual renderings in both groups is the child's involuntary movement during the image capture. Even with the noise toy distraction, the child may perform some craniofacial movement. However, even following the meticulous protocol, in three participants, it was not possible to perform manual rendering. In this way, a study[21] evaluated whether the head orientation influenced the accuracy of the 3D facial image. The authors concluded that the accuracy is not altered with the use of fixed stereophotogrammetry equipment, which makes the acquisition process simpler and less restricted to a predetermined position,[21] which is not always easy to achieve with all individuals, especially children. Therefore, the difference in the accuracy of automatic and manual rendering does not seem to have any influence on facial clinical aspects. However, it is emphasized that it is necessary to confirm these data through further studies, especially in the clinical use of portable stereophotogrammetry equipment.

A significant limitation in studies involving 3D facial analysis is precisely the movement that is intrinsic in any image processing, even for the acquisition of complex exams such as computed tomography. In the present study, because the children were younger than 27 months of age, cooperation and a restless nature may be a challenge.[9] Often, the light from the camera draws the child's attention and causes distraction, which prolongs the acquisition time, and additional captures may be necessary. However, in general, including all the explanations for the guardians, positioning of the child, and image capture, the average total time was 3–5 minutes. The speed of obtaining the images by the operator is also a key point; the faster and more practical, the shorter the time for the participant to move.[22] In addition, another difficulty encountered is the normalization of facial expression; in children, it is rare to achieve neutrality.[4,9,10] Therefore, further longitudinal studies are needed to evaluate the accuracy of these images and the extent to which the analyses are influenced by these aspects. In this study, no additional resources, such as general anesthesia or sedation, were used because the accessories of oro/nasotracheal intubation would interfere with image capture. In addition, the purpose of this study was to perform the imaging with awake participants. Thus, child management was essential, regardless of age.

Conclusion

It is concluded that the protocol for the use of portable stereophotogrammetry equipment in children during the first years of life helps the professional in the proper positioning and management for the acquisition of 3D facial images and allows standardization both for future studies and for use during clinical care.

Clinical Significance

Knowledge about the craniofacial development of children in early childhood is critical for diagnosis and clinical practice throughout childhood growth.

Author Contributions

All the authors have read, made significant contributions, and approved the manuscript. Débora R Quagliato was involved in the project, acquisition, study design, and wrote the manuscript. Ana BV da Silveira and Yana CT de Mello Peixoto were involved in the project, acquisition, and wrote the manuscript. Eloá CP Ambrosio was responsible for the conception, wrote the manuscript, and reviewed it. Paula K Jorge, Cleide FC Carrara, Natalino L Neto, Thiago Cruvinel, and Maria AM Machado were involved in the project and reviewed the manuscript. Thais M Oliveira was responsible for the conception and study design and performed the final critical review. All authors read and approved the final manuscript.

Data Availability Statement

We confirm that the results reported in the manuscript are original and neither the entire work nor any of its parts have been previously published. The authors confirm that the article has not been submitted to peer review, nor has it been accepted for publication in another journal. The author(s) confirm that the research in their work is original, and that all the data given in the article are real and authentic. If necessary, the article can be recalled and errors corrected.

Ethics Approval Statement

Approval was granted by the Human Research Ethics Committee of the Bauru School of Dentistry, University of São Paulo, and Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo, under the CAAE numbers: 71333223.1.0000.5417 and 71333223.1.3001.5441.

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