

Forensic facial reconstruction using CBCT – A systematic review

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Systematic Review

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Abstract

Objectives

This systematic review evaluated whether CBCT is a better diagnostic tool in facial forensic reconstruction. Forensic facial reconstruction is a technique to reconstruct human face from unidentified face from skull remains for human identification and facial recognition.

Materials and methods

Article selection and data extraction was done based on the inclusion and exclusion criteria devised for the study. The articles were screened from PubMed, ProQuest, Google scholar, Science direct and Scopus.

Result

Three hundred and thirty-nine articles were initially identified from which seven articles were full text reviewed and included in the review. All the articles included in this study suggest that the facial reconstruction done using CBCT are reliable.

Conclusion

The computerized 3D modeling method produces reliable facial reconstructions which involves the images scanned from CBCT and the combination method. The computerized 3D modeling method produces facial reconstruction which almost mimics the original resemblance.

Introduction

Forensic facial reconstruction is a technique to reconstruct human face from unidentified face from skull remains for human identification and facial recognition.¹ These techniques are used as a last option and also when the human remains are of recent origin which has not been identified. In these scenarios, an attempt is made to produce a facial like appearance of the individual which can be used to collect information that can help in possible identification. It can't be used as a direct identification but can be used as a tool to assist in identification. Scientific and artistic skills are essential in facial reconstruction.² In order to recognize a non- identity person, face of the person plays a major role which has got exclusive features to identify. Once it is reconstructed it would be easier to publish in Televisions and Newspaper for the relatives of the person to identify them. In some scenarios, the victim may be completely deformed due to animal attack, bomb blast or due natural disasters, that is where Facial forensic reconstructions help to identify the person with little or no info. ⁶

The methods which are used in the facial reconstruction are two-dimensional, three-dimensional clay models and three-dimensional computerized modelling.³ The manual and the computerized technique are the two methods which are used in 3D forensic facial reconstruction. 3D computerized craniofacial forensic reconstructions (CCFR) has got various advantages over other techniques by use of computer which enhance the visualization of the tools that shows skin and bone together with adjustments.⁴ The other advantages of CCFR include easy assemble of the skull parts without damaging the skull and can easily replace the left out or empty areas.⁵ But some disadvantages are also encountered that is, it is very time consuming and experience is necessary for the reconstruction.⁵ The various 3D manual methods which are in practice are the Anatomical (Russian), Anthropometrical (American) and Combination Manchester (British) methods which were developed by Gerasimov, Krogman and Neave respectively.⁷ The main aim of this systematic review is to evaluate whether CBCT is a better diagnostic tool in facial forensic reconstruction.

Materials And Method

Ethical approval from the Institutional review board was obtained. The substructure of the systematic review is based on PRISMA Statement. The focused question is "Is CBCT a better investigation tool for forensic facial reconstruction?"

Study design

This systematic review evaluated whether CBCT is a better diagnostic tool in facial forensic reconstruction.

Eligibility criteria

Inclusion criteria

Studies in which the primary objective was to evaluate the accuracy of a facial reconstruction technique using CBCT data. No language or time restriction were applied.

Exclusion criteria

Exclusion criteria included case reports, studies which included samples of facial anomalies and samples of orthognathic surgeries, studies done on two-dimensional facial approximation, reviews, letters, personal opinions, book chapters, conference abstracts and studies using animal models.

Information sources

The following databases were incorporated in the systematic search for relevant literature: PubMed, ProQuest, Google scholar, Science direct and Scopus. All searches were conducted from December 20 to January 10 2021

Search terms

Following search terms were used forensic facial reconstruction, CBCT and forensic facial reconstruction, facial approximation, craniofacial reconstruction, role of CBCT in facial reconstruction.

Study selection

In the 1st phase of selection, the titles and abstracts were screened and evaluated.

In the 2nd phase of selection- Full text were screened and study which have the inclusion and exclusion criteria were selected

Collection process

For all the included studies, following descriptive characteristics were recorded Author, year of study, location, ancestry, sample size, mean age of the patients included in the study, 3D manual methods used in the study for facial construction, type of machine used, sample type- live or deceased patients and results of the included study. One reviewer collected all the required information for the systematic review and other reviewer verified its accuracy.

Author	Year of study	Location	Ancestry	Sample size	Mean age	Method	CBCT machine	Sample type	Measurements analyzed in the study	Result
Hwang et al.,	2010	Korea	Korean	20	28.1	Computerized 3D CT images	Alphard Vega; Asahi Roentgen Co., Kyoto, Japan	Department data base	31 landmarks (10 midline and 21bilateral) were identified according to De Greef et al.,	The reproducibility of the facial thickness is reliable but some show low reproducibility. The landmarks of the 3D images can reproduce
Zacharias Fourie et al.,	2010	Netherlands	Netherlands	7	-	Computerized 3D CT images	KaVo 3D exam (KaVo Dental GmbH, Bismarckring, Germany) CBCT scanner	Cadaver	Facial soft tissue thickness at 11 different sites (soft tissue landmarks were measured)	Overall, result of study confirms that the measurements can be used to create a tissue data thickness
Won-Joon Lee	2012	Korea	Korea	3	28.4	Combination methods	Alphard Vega; Asahi Roentgen Co., Kyoto, Japan	3 student volunteers	the deviation errors between the reconstructed and target faces were measured.	Reconstruction of the facial features is reliable when compared to the facial
Wuyang Shui	2019	China	Han Chinese	140	-	Computerized 3D CT images	A Konica Minolta VIVID 910 laser scanner	140 living individuals (70 females and 70 males)	skull digitization, geometric measurements, sex classification and computerized CFR	Reconstruction of the unidentified face can reproduce
Yang Wen et al.,	2020	China	Han Chinese	200	17-75	Region fusion strategy	CT scanner	Volunteers	-	The results showed reconstruction of the facial thickness is reliable
Clemente Maia S. Fernandes	2012	Brazil	Brazilian female	1	-	Computerized 3D CT images	-	Volunteer	10 midline points and 11 bilateral points	The results of this study show that this is useful for facial reconstruction. The parameters used in the study.
Geraldo Elias Miranda et al.,	2017	Brazil	Brazilian Caucasian	4	21-49	Computerized 3D CT images	-	4 volunteers donated existing CT Data	Geometric comparison of the CCFR to the subject 3D face model (obtained from the CT data)	The two CCFRs were matched correctly at the accuracy levels of the free software programs produce 3D CCFRs and can be used in forensic applications

List of included studies and its main characteristics (Table -1)

Result Of Systematic Review

A total of 6754 articles were found in the various scientific database with search expressions relevant to this study, of these, 339 articles were selected for initial screening and from those 339 articles duplicates were excluded and the remaining was 159 articles. After abstract and text screening a total of 7

articles were finally selected for the study with the inclusion and exclusion criteria of the systematic review. The selection process of the include study is shown in Fig – 1.

Out of 7 studies which were included in the systematic review 5 studies used 3D computerized craniofacial forensic reconstructions, one study used combination method in facial reconstruction and one study used Region fusion strategy in facial reconstruction. The sample size of each study ranged from 1 to 200. The facial reconstruction in the included studies was done in live patients, existing CT data and cadavers.

The included studies analyzed various measurements which includes skull digitization, geometric measurements, sex classification and computerized CFR, Facial soft tissue thickness at different sites and the deviation errors between the reconstructed and target faces were measured. Majority of included studies analyzed facial soft tissue landmarks.

The result of the included studies indicates that the facial features of the reconstructions using CBCT data demonstrated good levels of accuracy.

Discussion

Facial soft tissue reconstruction plays a main role in identifying a deformed person with little or no information. It is very essential to know the average values of the facial soft tissue thickness of certain sites of the face to reconstruct the skull to some extent. Various studies on facial reconstruction have generated data base of soft tissue thickness related to BMI, gender, race and ethnicity. With the help of the database available on various ethnicity and productive use of CBCT, facial reconstruction is more reliable in individual identification and also can be used for archeological research.^{15,18}

CBCT produces feasible 3D craniofacial reconstructions, with a minimal radiation exposure. It is mainly appertaining to maxillofacial region. Its different field of views (FOV) produces excellent images of the skull and also the landmarks used in cephalometric analysis along with a 3D volumetric of external facial surface.¹⁶The various advantages of CBCT are as follows, can obtain the images in upright positions, lower radiation dose compared to CT, maximum tissue depth, can repeat the scans, editing of the images can be done on the go such as rotation and zoom views.¹⁷

There are different types of methods in facial reconstruction, which is manual and computerized 3D method. The manual method of facial reconstruction includes,

1. Anthropometrical American Method/ Tissue Depth Method

Krogman in 1946 developed Tissue Depth Method. The law enforcement agencies most commonly use this method of facial reconstruction. The needles, X-rays and/or ultrasound are used for taking the measurements. Highly trained personnel is needed for this technique to record the facial muscles in correct anatomic position, hence this technique is not preferred now a days.

2. Anatomical Russian Method

Gerasimov in 1971 introduced this method of facial approximation. The soft tissue depth data is not necessary for this technique. The approximation is performed by shaping the muscles, glands and cartilage onto the skull layer by layer. This method is not used now a days since it requires deeper anatomical acknowledge on performing the facial construction. Reconstruction of fossilized skulls can be done using this method.

3. Combination Manchester Method/ British Method

This method was introduced by Neave in 1977. This is the most accepted method and most widely used than the other two. It uses both the tissue depth and muscles.

Computerized 3D facial reconstruction

The 3D computerized models can be fabricated using both the manual clay and 3D animation software techniques and virtual sculpture system can also be used. In this method multiple images of the same face can be created most effectively.^{18,20}

The included studies in this systematic review used either the manual or computerized 3D facial reconstruction, but majority of the included studies opted computerized 3D forensic facial reconstruction method. The included studies in this systematic review suggest that the facial construction using CBCT are reliable.

Conclusion

The computerized 3D modeling method produces reliable facial reconstructions which involves the images scanned from CBCT and the combination method. The computerized 3D modeling method produces facial reconstruction which almost mimics the original resemblance.

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Declarations

Competing interests: The authors declare no competing interests

Figures

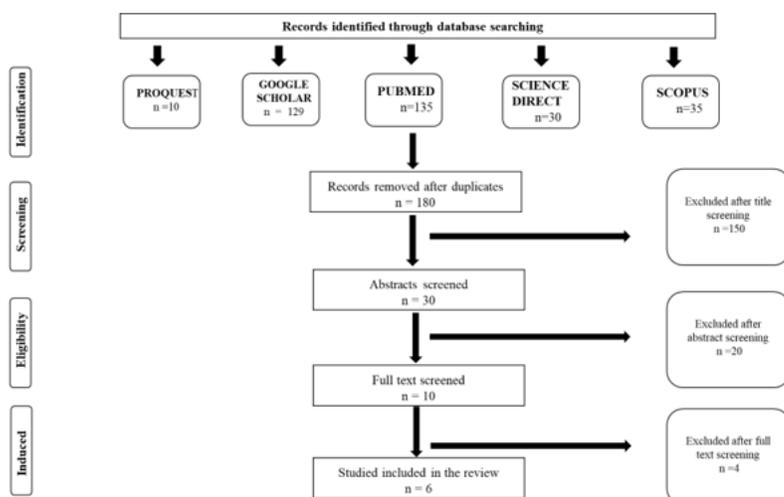


Figure 1

