ORIGINAL ARTICLE

Tooth reconstruction in forensic situations through dental materials: An anatomical art

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Abstract

Introduction: Dental identification is a frequently applied method of forensic investigation, in mass disasters, accidents, and criminal investigations, where the human remains are decomposed, charred, or skeletonized. However, in such events, teeth may dislodge due to postmortem loss or mishandling during transporting and packaging which may further hamper with the identification of an individual. **Aim:** To investigate the potential for reconstruction of missing teeth utilizing dental materials. **Subjects and Methods:** Impressions of the intra-alveolar morphology of the empty sockets of a mandible were taken utilizing different impression materials. Positive replicas were prepared, and the profile of the missing/absent dental roots and crowns was constructed. Standardized radiographs were taken to assess the reliability of the method. **Results:** Based on the subjective observation, the combination of light body and heavy body (Putty)-addition silicone (for negative replica), self-cure (pink-colored) resin (for positive replica), and flowable composite resin (for reconstruction) gave the best outcome among the materials used. **Conclusion:** Tooth reconstruction utilizing dental materials that may help in comparative identification.

Key words: Dental identification, dental materials, dental reconstruction, forensic, postmortem loss

Introduction

Dental identification is a frequently applied method of forensic investigation, especially in mass disasters, accidents, and criminal investigations, where the human remains are decomposed, charred, or skeletonized. Dental analysis is considered as one of the primary methods for human identification according to Interpol.[1] Human identification through dental analyses is by comparative identification.[2,3] It is a reliable and frequently applied method which predominately relies on comparison of antemortem (AM) and postmortem (PM) records.[2] These comparisons are based on AM data, which are retrieved from clinical records obtained from dental offices where the patient had undergone treatment, and PM data, which are obtained from the dentoskeletal remains of the deceased.[3] Teeth, especially the enamel, by virtue of being the most calcified structures in the human body, are invariably found in most mass disaster events.[3] However, in such catastrophic events, there is a possibility that the teeth may be dislodged due to PM loss or in case of mishandling during the manipulation of skeletal and dental remains.

Access this article online	
Website: www.jfds.org	Quick Response Code
DOI: 10.4103/jfo.jfds_92_18	

How to cite this article: Jani G, Johnson A. Tooth reconstruction in forensic situations through dental materials: An anatomical art. J Forensic Dent Sci 2018;10:137-42.

PM loss of the tooth from their sockets may be due to factors relating to natural process of skeletonization that causes destruction of periodontal tissues, which may lead to loosening of teeth.[4] Single-rooted teeth are affected the most due to their anatomical shape.[4] Macroscopically, teeth may be considered missing during PM examination, when they present as empty and unhealed dental sockets with sharp bone crests.[4-6] Radiographically, empty sockets of such missing teeth show a thin radiopaque lamina dura outlining the root-shaped intra-alveolar morphology.[6] In such cases, assessment of intra-alveolar morphology of empty dental socket may help in reconstructing the shape of missing roots, thus adding an element for identification.[7]

Forensic tooth reconstruction refers to the process that aims to reconstruct the morphology of the missing tooth of the skeletal remains from the intra-alveolar morphology of dental sockets. Morphologically, dental root traits contribute distinctively in comparative identification and also in population differentiation.[8] Accuracy in tooth reconstruction is improved with computed tomography imaging which enables a three-dimensional assessment of root morphology.[6,9] Medico-legal institutes lack advanced radiographic facilities; hence, simple techniques utilizing readily available dental materials may be required. Thus, the present study aims to investigate whether dental materials recording intra-alveolar morphology have potential in dental reconstruction of missing teeth.

Subjects and Methods

An *in vitro* experimental study was undertaken on a human mandible with known age, sex, and race from the skeletal archives of Laboratory of Forensic Odontology of Gujarat Forensic Sciences University, Gandhinagar, Gujarat, India.

The mandible presented according to Fédération Dentaire Internationale charting: left third molar (38), left second molar (37), left first molar (36), left first premolar (34), left lateral incisor (32), left central incisor (31), right central incisor (41), right lateral incisor (42), right canine (43), right first premolar (44), right first molar (46), right second molar (47), and right third molar (48) [Figure 1a]. Teeth were removed manually from the sockets simulating teeth missing PM: left third molar (38), left second molar (37), and left first molar (36) [Figure 1b]. Intra-alveolar inspection was performed which indicated full morphological integrity and lack of foreign bodies. Radiographic assessment was digital with radiovisuography (RVG) (Vatech, at 60 kvp/2.5 ma, 0.12 s) to assess the morphology of the socket [Figure 2a and b].

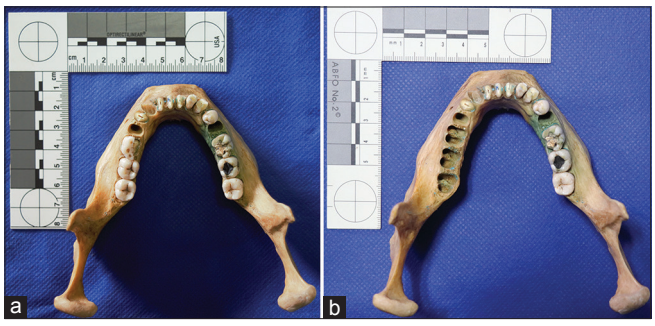

Figure 1: Occlusal view of human mandible; before removal of teeth (a) and after removal of teeth (b)

The entire study was conducted in three phases with different dental materials.

Phase 1 comprised of preparation for negative replica where an impression was taken using a perforated lower metal tray with the following impression materials.

- Material #1 Alginate (Zhermack Neocolloid Alginate-ADA Sp. no. 18)
- Material #2 very heavy body (putty) addition silicone (Adsil Acura Soft Putty-ADA Sp. no 19)
- Material #3 combination of very heavy and light body addition silicone (Aquasil Ultra LV/XLV Smart Wetting® Regular Set, Densply-ADA Sp. no 19)
- Material #4 Impregum Soft Polyether Impression Materials (3M ESPE-ADA Sp. no 19).

Phase 2 comprised of preparation of a positive replica or cast. Materials used were: (1) Material #5 Type-2 gypsum product dental plaster (White Gold-ADA Sp. No. 25); (2) Material #6 Type 3 gypsum product dental stone (Gold stone-ADA Sp. No. 25); (3) Material #7 self-cure resin pink-colored (ASHVIN Rapid Repair-ADA Sp. No. 17); (4) Material #8 clear resin (DPI-RR Cold cure-ADA Sp. No. 17).

In Phase 3, an attempt was made to reconstruct the tooth using the following dental materials:

- Material #9 self-cure resin (ASHVIN Rapid Repair-ADA Sp. No. 17)
- Material #10 flowable composite (IvoClar Vivadent TE-ADA Sp. No. 27)
- Material #11 inlay wax (Kerr-green inlay casting wax-ADA Sp. No. 4)
- Material #12 temporary acrylic crown resin (Detax Dental tempofit duomix refill-ADA Sp. No. 17).

For retrieval of the material from the socket, an endodontic file no. 40 was used. For crown preparation, the impression

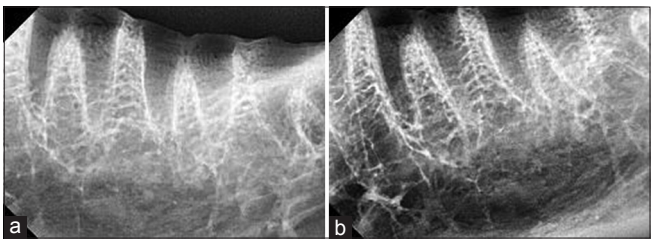

Figure 2: Digital radiograph taken after removing the following tooth: left third molar (38), left second molar (37), left first molar (36) (a and b) from the socket to assess the morphology

of Typodont teeth (API) was taken and the crown was prepared with composite. The tooth was slightly modified at crown portion in height and width based on the dimension of the opposing tooth. The reconstructed tooth was compared with the specimen tooth (the ones removed from the socket) [Figure 3] and then were placed into the socket [Figure 4a] with digital radiograph using RVG to check the adaptation of reconstructed tooth in dental socket [Figure 4b and c].

Results

The tooth reconstructed was compared with the specimen tooth (removed from socket), and the length of reconstructed root was measured using digital vernier calipers which showed discrepancy of 0.5–1 mm. The radiographs showed appropriate adaptability [Figure 4b and c]. The dental materials used for the reconstruction were examined and validated on various criteria. The results for Phase 1, Phase 2, and Phase 3 were based on various parameters, where each parameter for individual material was scored from 1 (highly satisfactory) to 4 (unsatisfactory) in relation to other materials based on the subjective observation. The cumulative score for each material was calculated and based on the score obtained; the materials were graded as Grade 1 (5–9), Grade 2 (10–14), and Grade 3 (15–20). Grade 1 materials were considered to have satisfactory outcomes in regard to forensic routine.

The results for Phase 1 (i.e., preparation of negative replica was based on intra-alveolar flow, registration of apical morphology, tensile strength, complexity of technique, affordability of the material) are summarized in Table 1. Based on the parameters, the materials were ranked as #3>#4>#2>#1. The most appropriate material based on the outcome and details of the impression was combination of very heavy (Putty)-light body-addition silicone [Figure 5], whereas alginate and very heavy body-addition silicone were scored as least owing to their incapability to flow and record intra-alveolar morphology of multi-rooted teeth and were least satisfactory. Polyether was ranked second owing to its high cost.

The results for Phase 2 (i.e., preparation of positive replica or cast was based on accuracy of surface details, voids, strength and durability, color contrast, and affordability of materials) are presented in Table 2. Based on the scoring, the materials were ranked as #7>#8>#6>#5. The most appropriate material based on the outcome and details of the impression was self-cure resin (pink resin) [Figure 6]. The self-cure resin (clear) was ranked second according to the score because of the color contrast with most Phase 3 materials and its high cost. Material #5 and #6 were scored least owing to its strength and durability compared to other materials and no color contrast.

The results for Phase 3 (i.e., tooth reconstruction were based on flow, retrieval of structure, potential to imitate morphology of root, radiopacity, and affordability of the material) are presented in Table 3. Based on the scoring, the materials were ranked as #10>#12>#9>#11. The most appropriate material was composite resin [Figure 7] though there was discrepancy of 0.5–1 mm due to polymerization shrinkage. Temporary crown resin ranked second owing to its lesser radiopacity compared to composite whereas Material #9 and #11 were least satisfactory.

Figure 3: Comparison of the reconstructed teeth with natural teeth

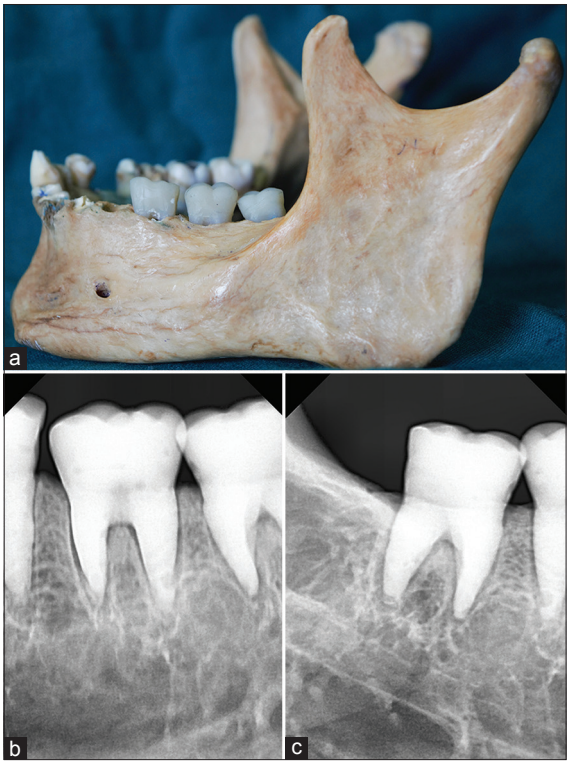

Figure 4: Placement of reconstructed teeth in the mandible (a) and taking the radiograph (b) and (c) to check the adaptability

Table 1: The results for Phase-1, i.e., preparation for negative replica were based on intra-alveolar flow, registration of apical morphology, tensile strength, complexity of technique, cost of the material

Parameters	Material #1 Alginate	Material #2 Very heavy body (putty) addition silicone	Material #3 Combination of very heavy (putty)-Light body addition silicone	Material #4 Polyether
Intra-alveolar flow	3	4	1	1
Registration of morphology	4	4	1	1
Tensile strength	4	2	1	1
Complexity of technique	3	2	2	3
Affordability of materials	2	3	4	4
Total	16	15	8	10
Scoring criteria				
Criteria for individual score			**Cumulative score**	
1: Highly satisfactory			Grade 1: 5-9	
2: Moderately satisfactory			Grade 2: 10-14	
3: Least satisfactory			Grade 3: 15-20	
4: Unsatisfactory				

*Lesser the score better the material

Table 2: The results for Phase-2, i.e., preparation for positive replica or cast were based on accuracy of surface details, voids, strength and durability, color contrast and cost

Parameters	Material #5 Type 2 Gypsum product	Material #6 Type 3 Gypsum product	Material #7 Self - cure Resin (pink)	Material #8 Self-cure resin (Clear acrylic)
Reproducibility of surface details	4	3	1	1
Strength and durability	3	2	1	1
Colour contrast	4	4	1	4
Voids	3	3	2	2
Affordability of materials	2	3	3	4
Total	16	15	8	12
Scoring criteria				
Criteria for individual score			**Cumulative score**	
1: Highly satisfactory			Grade 1: 5-9	
2: Moderately satisfactory			Grade 2: 10-14	
3: Least satisfactory			Grade 3: 15-20	
4: Unsatisfactory				

*Lesser the score better the material

Table 3: The results for Phase-3, i.e., tooth reconstruction were based on flow, retrieval, potential to imitate morphology of root, radiopacity, and affordability of the material

Parameters	Material #9 Self-cure acrylic	Material #10 Flowable composite	Material #11 Inlay wax	Material #12 Temporary crown resin
Flow	4	1	1	1
Retrieval of material	1	1	3	1
Imitation of morphology	4	1	2	1
Radiopacity	4	1	4	2
Affordability of materials	3	3	1	3
Total	16	7	10	8
Scoring criteria				
Criteria for individual score			**Cumulative score**	
1: Highly satisfactory			Grade 1: 5-9	
2: Moderately satisfactory			Grade 2: 10-14	
3: Least satisfactory			Grade 3: 15-20	
4: Unsatisfactory				

*Lesser the score better the material

Hence, the best outcome regarding the benefits of the techniques and materials were combination of very heavy (Putty)-light body-addition silicone, self-cure resin (pink resin), and composite resin for reconstructing the tooth.

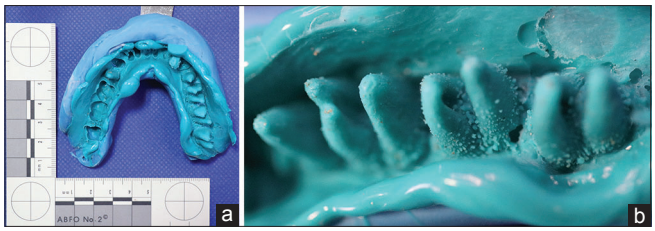

Figure 5: (a and b) Phase 1- Impression was taken using a combination of very heavy (Putty) and light body addition silicone

Figure 6: Phase 2 - Positive replica was made using self-cure resin (pink-colored resin)

Figure 7: Phase 3 - Reconstruction of the tooth using composite resin

Discussion

Dental identification of a deceased individual is a core task in forensic odontology. According to Interpol disaster victim identification guidelines, in PM phase photography, ridgeology (fingerprints), radiology, odontology, DNA sampling, and autopsy procedures are included.[1] However, in cases of skeletonized, charred, and decomposed remains, most of the methods cannot be applied. Dental tissue, especially enamel being the hardest biological substance in the human body, and posterior teeth being well protected by soft tissues (the tongue, facial musculature, and adipose tissue) survive prolonged immersion, decomposition, desiccation, extensive trauma, and direct heat in excess of 1000°F;[3,10,11] thus, dental structures prove to be identifiers. However, due to decomposition of oral and paraoral tissues and mishandling of remains, teeth may dislodge from the socket during PM manipulation of human remains, which hampers the human identification process. Although teeth missing PM are included in the list on Interpol dental codes for human identification,[12] the remaining empty sockets did not receive major attention.[6] Hence, alternative techniques are necessary to overcome these limitations and improve the collection of PM dental data.

Smith[7] in 1992 investigated the forensic application of the root morphology of teeth missing PM, where they also reconstructed the morphology of missing root by adding radiopaque mixture of vinyl polysiloxane and barium sulfate into the empty dental sockets of skeletal remains. The technique allowed radiographic comparison of dental information. Further, the literature mentions the use of mixture of alginate and barium sulfate to reconstruct a radiopaque outline of missing roots.[13] Capeletti *et al*.[6] in 2017 revealed that materials such as vinyl polysiloxane may give optimal outcome if proper techniques and materials are used and thus aid in reconstructing the root morphology clinically. The present study was designed as an initial step toward reconstructing the morphology of a tooth from dental materials for identification purpose in forensic context.

Dental materials are readily available from a dentist and have the advantage of being designed for oral structures and hence they mimic the oral and paraoral structures the best. In addition, dental materials are comparatively cheaper than three-dimensional radiographic techniques and can be afforded by medico-legal institute lacking high-tech radiographic techniques. The best outcomes regarding the benefits of the techniques and materials were combination of very heavy (Putty) and light body-addition silicone for impression preparation, self-cure resin (pink resin) for preparation of cast, and finally, flowable composite resin for the preparation of tooth which is readily available from a dentist.

In routine forensic casework, the reconstructed tooth root aids in comparative identification when AM records are available as the root traits are potentially distinct; this may also help in population differentiation, especially in disasters which involve victims from different countries and continents.[6] This would also aid in swift and accurate morphometric analysis of roots. Further, intra-alveolar morphology reproduced enables assessment of root developmental stage that might also aid in age estimation,[6,13,14] though further studies are indicated in this field. Apart from comparative identification, it may also help in reconstructive identification. The position and protrusion of the teeth would also play an important

role in determining the shape, thickness, and position of lips,[15] which would ultimately be beneficial in forensic reconstruction. Thus, reconstruction of a missing tooth can aid in defining lips giving an added advantage for facial reconstruction.

The limitation of the present approach is that it is time-consuming and cannot be utilized in putrefied, charred, or brittle remains. It becomes difficult to apply this technique in cases where the socket walls are damaged or fractured. In cases of root anomalies such as dilaceration, selection of the appropriate dental materials as well as proper technique becomes an important factor for desired results.

Conclusion

The absence of tooth does not necessarily invalidate the dental identification. An attempt to reconstruct the teeth with dental materials by recording the intra-alveolar morphology of the dental root socket validates that the dental information can be retrieved even if the teeth are missing PM. Dental materials mimic the oral structures the best, and thus, the knowledge of dental materials and the expertise of a dentist play an important role in forensic context. For optimal outcome, the combination of heavy (Putty) and light body addition silicone (Phase 1), self-cure resin (pink resin) (Phase 2), and flowable composite (Phase 3) can be utilized. This technique can be reproduced not only in high-tech forensic facilities but also in medico-legal institutes that cannot afford imaging services. In future studies, the limitations inherent to the present research can be approached and improved with newer materials and techniques as they become available.

Acknowledgment

The authors thank Dr Binita Gandhi, Prof. and Head, Department of Oral and Maxillofacial Pathology, College of Dental Sciences and Research Centre, Ahmedabad and Dr. Pritam Panja, Dental Diagnostician, Kolkata for their valuable guidance and support for this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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