G37 Testing a Novel 3D Printed Radiographic Imaging Device for Use in Forensic Odontology

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After attending this presentation, attendees will better understand specific forensic odontology challenges related to radiology, including lack of occlusion and difficulties in aligning X-ray equipment to teeth of interest, and will learn more about a new device.[1]

This presentation will impact the forensic science community by providing research on how 3D printing technology can be used to create a novel alignment device, the Combined Holding and Aiming Device (CHAD), as a way of addressing the positioning limitations of current aiming devices and those specific to forensic odontology.

Distinct dental features remain one of the most efficient Postmortem (PM) identifiers.[2] Dental identifications have been made on a single tooth alone.[1] An important part of the dental identification process is accomplished by comparing Antemortem (AM) radiographic images and dental records to PM images. Limitations of radiographic identifications based on AM and PM image comparisons are well described in the literature as "labor-intensive, subjective, of poor image quality, and containing insufficient dental anatomy for differentiation among teeth and other dental anatomy."[2,3] Specifically, common technical errors related to dental radiographic exposure include film packet and/or sensor placement and angulation discrepancies.[1] 3D printing technologies have been deemed "the next industrial revolution" and are predicted to change health care delivery models in both medicine and dentistry.[4] 3D printing has gained popularity in dentistry because parts, equipment, and products can be customized and produced at a low cost.

This presentation contributes to the forensic community by proposing a new device designed to help hold X-ray aiming equipment onto teeth of interest for the purpose of allowing dental professionals to more accurately obtain precise X-ray images on victim remains. The CHAD has a sliding lock mechanism that securely adheres to and adjusts to the tooth, including those that may be broken or chipped (Table 1). Overall, the CHAD has the following capabilities: (1) it allows portable X-ray equipment to align with the CHAD, and, (2) it keeps the X-ray sensor or film in place and in alignment with dental remains while PM X-rays are taken; and, (3) it facilitates infection control as it is made of disposable biodegradable plastics.

	Mean	Standard Deviation	p value
Total Error Scores			
Device A	14.833	5.18	0.0015
Device B	9.853	4.63	
Device C	13.333	5.05	
Packet Placement Errors			
Device A	4.250	2.967	0.1716
Device B	2.958	2.255	
Device C	4.208	2.750	
Angulation Errors			
Device A	7.166	2.098	<.0001
Device B	4.500	4.500	
Device C	6.750	6.750	
Miscellaneous Other Errors			
Device A	0.041	0.204	0.6965
Device B	0.125	0.612	
Device C	0.041	0.204	
Angulation Sub-Categories			
Device A	0.042	0.204	0.0206[a] 0.0498[b] 0.0206[c]
Angulation 4	0.666	1.167	
Angulation 5	0.250	0.608	
Angulation 6	1.041	1.267	
Angulation 7	1.292	1.398	<.0001
Device B			
Angulation 4	4.500	1.933	
Angulation 5	0.333	0.963	
Angulation 6	1.083	0.974	
Angulation 7	0.250	0.675	<.0001
Device C			
Angulation 4	6.750	2.251	
Angulation 5	0.125	0.448	
Angulation 6	1.958	1.681	
Angulation 7	0.042	0.204	<.0001

Table 1: Total and Angulation Error Sub-categories for Device A, B and C

Means (M), Standard Deviations (SD), p values for comparisons of each technique by total error scores and error scores by category.

[a]*ANOVA*

[b]*Levene's Test for Homogeneity*

[c]*Brown and Forsythe's Test for Homogeneity*

Fragmented real human skulls were used to test and compare the CHAD to existing holding devices, specifically wax and a Modified External Aiming Device (MEAD). Participants (*N*=24) exposed six X-rays per device for a total of 432 X-rays scored.

Analysis of Variance (ANOVA) was used to compare sum of the errors for each device A (wax), B (MEAD), and C (CHAD). A significant difference was found at the .05 level between the three devices (*p*=.0015) (Figure 3). The means showed that devices A and C performed about the same (*p*=.3152); however, devices A and C were significantly different from B. In other words, B had significantly lower errors than devices A and C. Devices B and C were now compared. As expected, device B performed better in terms of minimal error than device C (*p*=0.0102). Comparing devices, A and B, the *p*-value revealed that there was a significant difference in overall errors (*p*=.0006).

The ANOVA test exhibited no significant difference in total "packet placement" errors between the three devices (*p*=.1716). Results are summarized in Table 1. A *t*-test analysis found there was significant difference between all four of the subcategories of angulation errors (Angulation error 4-7) (p<.0001) with incisal edge/apices cut off as the highest number of errors (*M*=4.500) and horizontal overlap as the next highest error (*M*=1.083) within device B. Overall, total errors were higher in device A (soft dental wax only), and device B and C performed better than device A — these results support existing literature on the use of holding devices in PM radiographic imaging.

In conclusion, the CHAD combines the benefit of being an "all-in-one" device because it is able to be 3D printed with its own holding and aiming mechanisms — in this way, the CHAD can keep the X-ray sensor or film in place while PM X-rays are taken. Additionally, it needs no modifications or wax for use. Identification of ways to minimize retake errors is needed to ensure radiographers can take accurate dental X-rays with proper angulation and in an efficient way for AM and PM records comparison and victim identification efforts.

Reference(s):

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Forensic Radiology, Forensic Odontology, Victim Identification