3D printing applications in forensic medicine

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BACKGROUND AND AIM: 3D printing technology (or additive manufactury or rapid prototyping or 3D modeling) is a reliable and inexpensive manufacturing technique to create three dimensional physical objects from digital models using a 3D printer. A 3D printer is a machine that can turn a blueprint into a physical object usually created with a computer aided design (CAD) program running on a desktop computer. In medical field graspable objects are based on acquired and post-processed radiological image data [1] and are made by fusing or depositing materials – such as plastic, metal, ceramics, powders, liquids – layer by layer[2,3,4] Medical applications for 3D printing are expanding rapidly and are expected to revolutionize healthcare [2] 3D printing can be used in forensic science realizing a precise replica of the body anatomy from computed tomography (CT) and magnetic resonance imaging (MRI) scans. 3D prototyping helps to maintain forensic evidence: it allows anatomically correct recreations of lesions – producing a realistic representation of their shape, depth, and texture – and of forensic findings. The study aims to investigate 3D printing forensic applications.

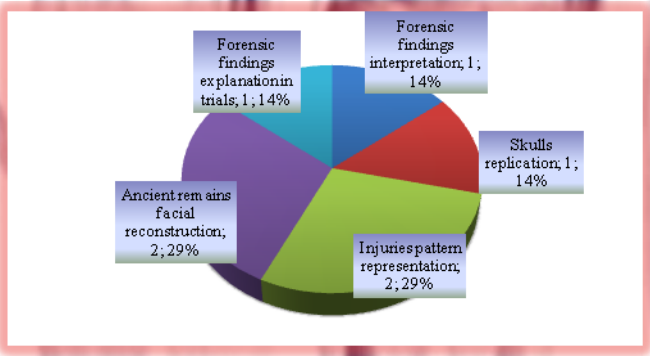

Fig.1 Reports distribution

METHODS:. A research of Medical Subject Headings terms (additive manufacturing) OR (rapid prototyping) OR (3D modeling) OR (3D printing) AND (forensic) was performed in the US National Library of Medicine. We found 33 references; all articles with potentially relevant material were examined in detail, leading to the final identification.

RESULTS: 7 reports dealing with 3D printing and forensic pathology were found, showing scant literature on this topic. In 1 paper (14,28%) skeletal remains were examined explaining how 3D modeling permits a better understanding of taphonomic agents and a detailed interpretation of findings[5]. In 1 (14,28%) article results coming from two different acquisition techniques (CT scanning and laser) of skull images were compared [6]. Two (28,58%) papers underlined the importance of physical representation of injuries primary pattern (that could be lost because of tissue changes) to determine the onset mechanism, identifying weapons and forces exerted on the body [7,8] One (14,28%) article reported 3D models usefulness in trials for a better explanation of forensic findings, allowing to determine how a crime may have been physically carried out[9]. Showing of shocking images is also avoided and models are suitable for medical training. Moreover, the method is respectful towards dead's dignity and medical ethics. Finally, 2 (28,58%) reports displayed the rapid prototyping use in facial reconstruction of ancient remains: an Egyptian mummy (whose recreation would not have been possible without altering bandages) [10]and a Classical Grecian skull [11].

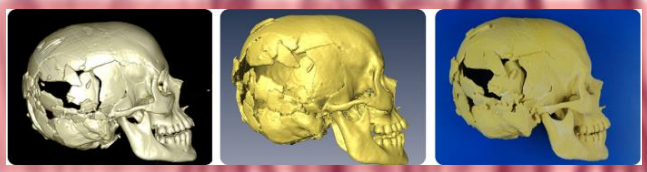

Fig.2 Fractured skull reconstruction (Ebert et al., 2011)

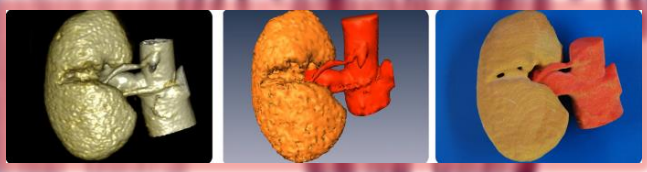

Fig.3 Ruptured kidney reconstruction (Ebert et al., 2011)

CONCLUSIONS: Despite the lack of wide ranging scientific literature on this topic, the findings confirm the advantages related to 3D modeling based on virtual imaging in forensic pathology. It definitely overcomes the limitation of 3D visualizations which can only be displayed on flat screen. Hence, additive manufacturing has the potential to be broadly employed in forensic applications due to its affordability and expected improvement in its accuracy. Nevertheless, since reproducibility is essential in forensics, further investigations are required to validate the technique.

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