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Fabrication of Antimicrobial Dental Model Using Digital Light Processing (DLP) Integrated with 3D-Bioprinting Technology

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Abstract : Background: Bio-fabrication is a multidisciplinary research field that combines several principles, fabrication techniques, and protocols from different fields. The open-source-software movement is a movement that supports the use of open-source licenses for some or all software as part of the broader notion of open collaboration. Additive manufacturing is the concept of 3D printing, where it is a manufacturing method through adding layer-by-layer using computer-aided designs (CAD). There are several types of AM system used, and they can be categorized by the type of process used. One of these AM technologies is Digital light processing (DLP) which is a 3D printing technology used to rapidly cure a photopolymer resin to create hard scaffolds. DLP uses a projected light source to cure (Harden or crosslinking) the entire layer at once. Current applications of DLP are focused on dental and medical applications. Other developments have been made in this field, leading to the revolutionary field 3D bioprinting. The open-source movement was started to spread the concept of open-source software to provide software or hardware that is cheaper, reliable, and has better quality. Objective: Modification of desktop 3D printer into 3D bio-printer and the integration of DLP technology and bio-fabrication to produce an antibacterial dental model. Method: Modification of a desktop 3D printer into a 3D bioprinter. Gelatin hydrogel and sodium alginate hydrogel were prepared with different concentrations. Rhizome of Zingiber officinale, Flower buds of Syzygium aromaticum, and Bulbs of Allium sativum were extracted, and extractions were selected on different levels (Powder, aqueous extracts, total oils, and Essential oils) prepared for antibacterial bioactivity. Agar well diffusion method along with the E. coli have been used to perform the sensitivity test for the antibacterial activity of the extracts acquired by Zingiber officinale, Syzygium aromaticum, and Allium sativum. Lastly, DLP printing was performed to produce several dental models with the natural extracted combined with hydrogel to represent and simulate the Hard and Soft tissues. Result: The desktop 3D printer was modified into 3D bioprinter using open-source software Marline and modified custom-made 3D printed parts. Sodium alginate hydrogel and gelatin hydrogel were prepared at 5% (w/v), 10% (w/v), and 15%(w/v). Resin integration with the natural extracts of Rhizome of Zingiber officinale, Flower buds of Syzygium aromaticum, and Bulbs of Allium sativum was done following the percentage 1-3% for each extract. Finally, the Antimicrobial dental model was printed; exhibits the antimicrobial activity, followed by merging with sodium alginate hydrogel. Conclusion: The open-source movement was successful in modifying and producing a low-cost Desktop 3D Bioprinter showing the potential of further enhancement in such scope. Additionally, the potential of integrating the DLP technology with bioprinting is a promising step toward the usage of the antimicrobial activity using natural products.

Keywords : 3D printing, 3D bio-printing, DLP, hydrogel, antibacterial activity, zingiber officinale, syzygium aromaticum, allium sativum, panax ginseng, dental applications
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