DENTAL APPLICATIONS OF ADDITIVE MANUFACTURING

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Credit: AI Picture Generator

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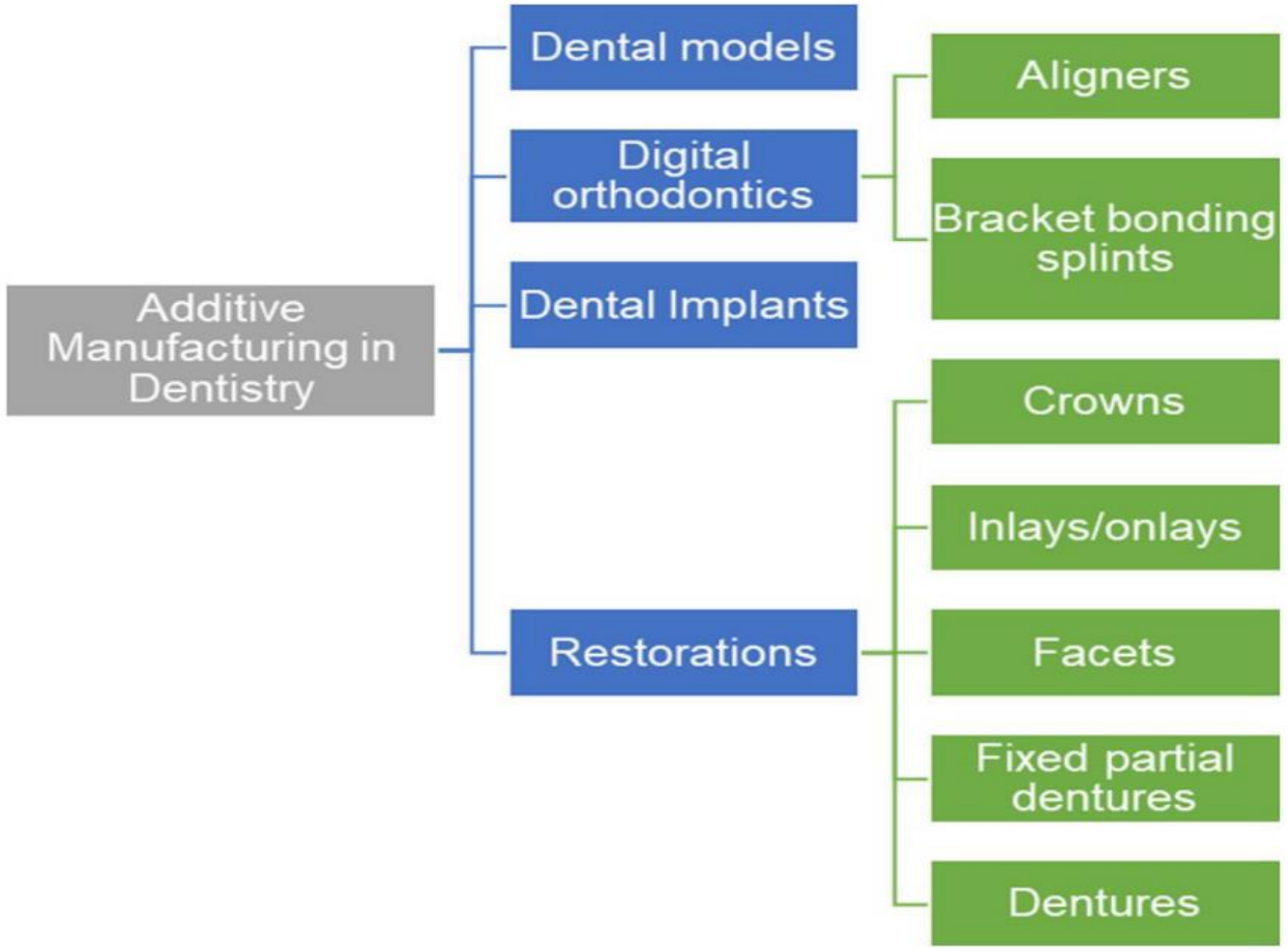
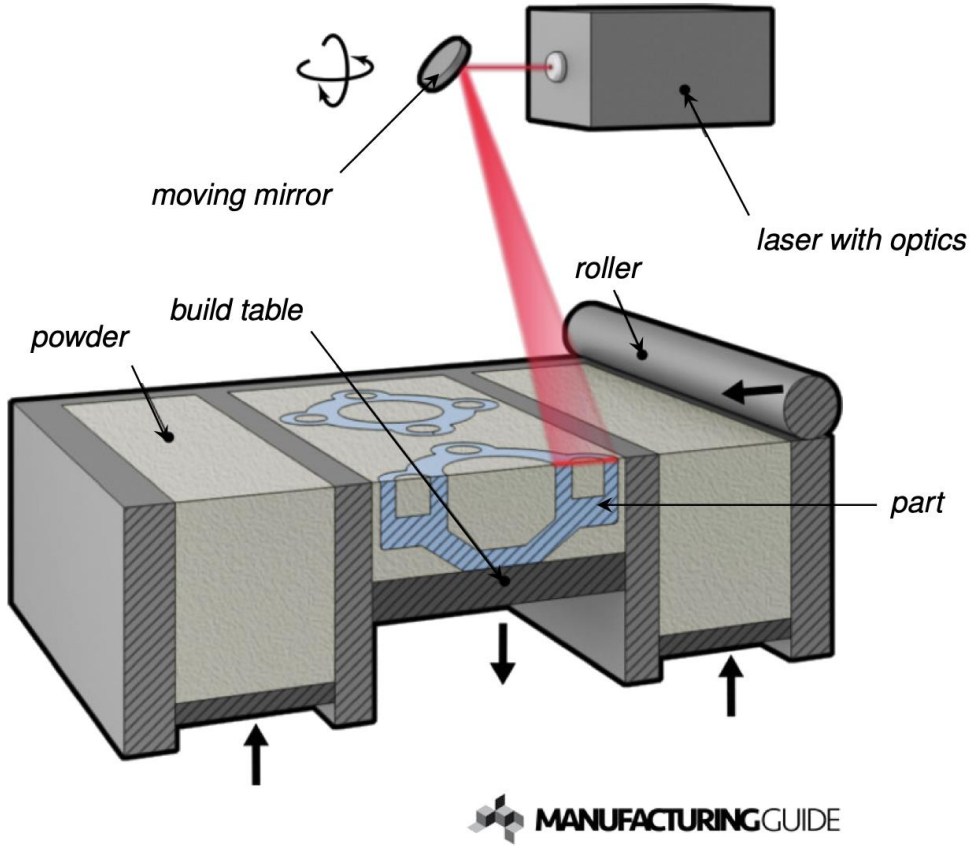
INTRODUCTION



Credit: *Additive manufacturing of ceramics for dental applications: A review. Raquel Sofia Cardoso Galante. April 2019. Dental Materials,* https://doi.org/10.1016/j.dental.2019.02.026.

SELECTIVE LASER SINTERING AND MELTING

- Powder-bed additive manufacturing process
- Build a piece layer by layer
- SLS is used with ceramic, polymer or glass powders
  - Ceramic in dentistry
- SLM for metal parts
  - Chrome cobalt or titanium parts in dentistry



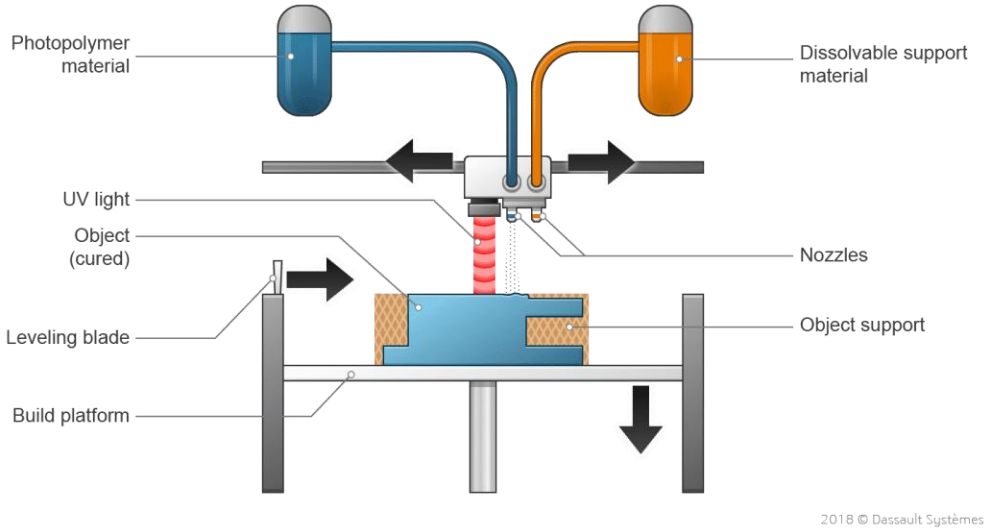
Credit: Chapter 4. Additive processes with powder base material. Brugger J. Moser C. Boillat, E.. 2024. URL: https://moodle.epfl.ch/pluginfile.php/2850040/mod_resource/content/18/CHAP4_PowderBasedProcesses_IMPRIMABLE.pdf

MATERIAL JETTING

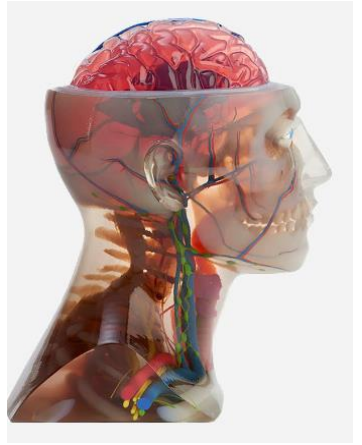
Deposition of droplets of a photosensitive material

Use UV light to set the droplets

Build layer by layer

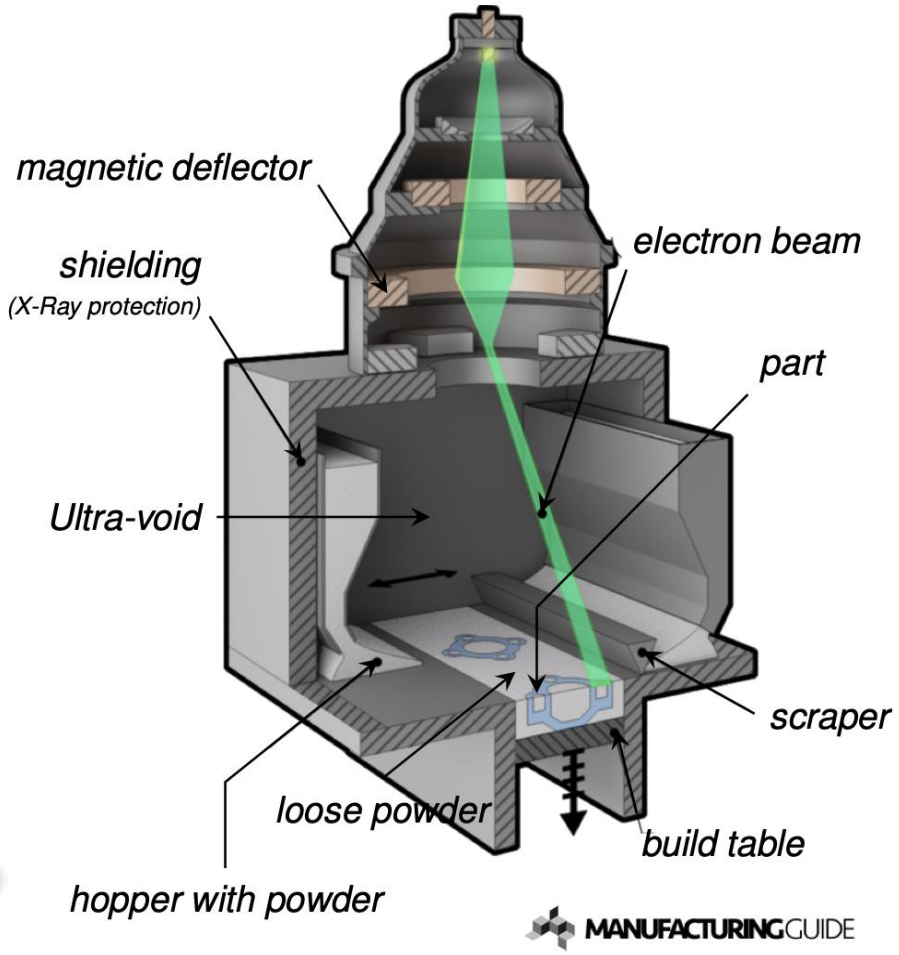


Key use : multi-materials and multi-colors parts



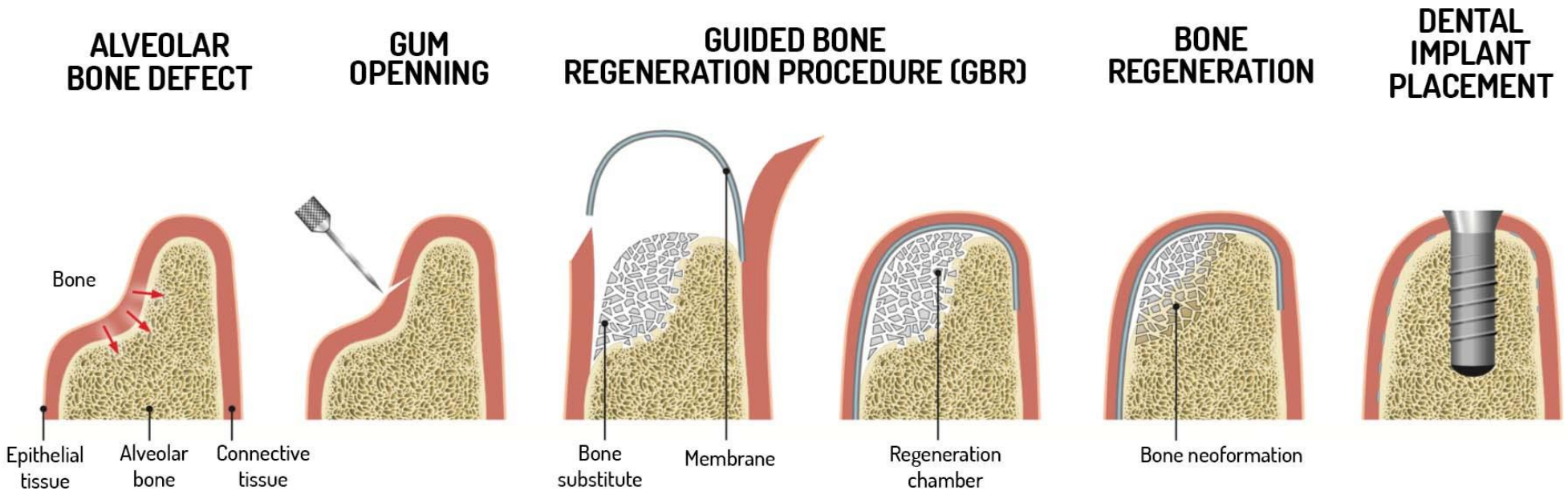
Credit:
Material Jetting. URL: https://www.3ds.com/make/guide/process/material-jetting
What is material jetting 3d printing? Protolabs Network, n.d. URL: https://www.hubs.com/knowledge-base/introduction-material-jetting-3d-printing/#what.

ELECTRON BEAM MELTING (EBM)



Credit: *Chapter 4. Additive processes with powder base material. Brugger J. Moser C. Boillat, E.. 2024. URL: https://moodle.epfl.ch/pluginfile.php/2850040/mod_resource/content/18/CHAP4_PowderBasedProcesses_IMPRIMABLE.pdf*

GUIDED BONE REGENERATION (GBR)

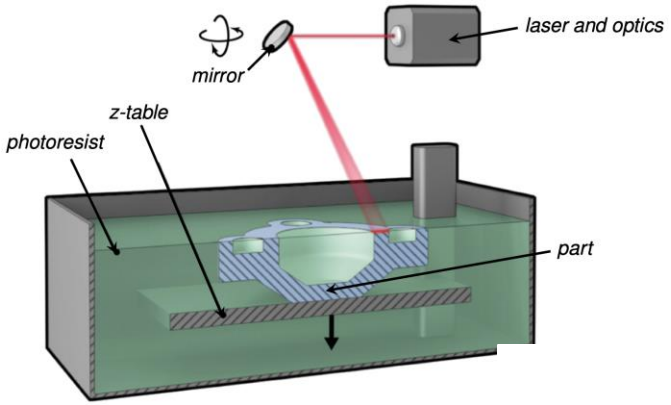


Credit: *Optimising bone regeneration in dentistry. Dorien Van Hede. January 31, 2022. URL: https://www.facmed.uliege.be/cms/c_7995259/en/optimising-bone-regeneration-in-dentistry*

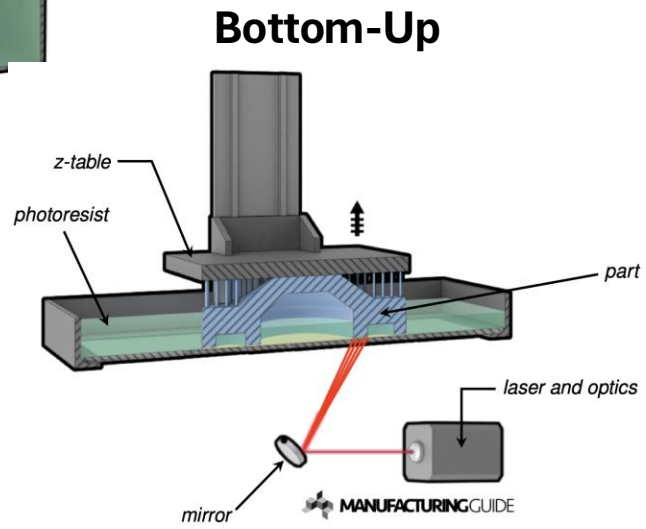
VAT PHOTOPOLYMERIZATION

STEREOLITHOGRAPHY (SLA)

Top-Down



Bottom-Up



- Liquid resin prepared in vat.
- UV laser cures resin, tracing design continuously.
- Galvanometric mirrors guide laser for precision
- Inhibitors prevent unwanted curing.
- Layers built continuously until object complete.

Credit: Chapter 2. Photopolymer based additive processes. *Brugger J. Moser C. Boillat, E.. 2024. URL:* https://moodle.epfl.ch/pluginfile.php/2836733/mod_resource/content/14/CHAP2_LiquidBasedProcesses_IMPRIMABLE.pdf

VAT PHOTOPOLYMERIZATION

DIGITAL LIGHT PROCESSING (DLP)

Liquid resin prepared in vat.

↓

UV flash cures entire layers at once.

↓

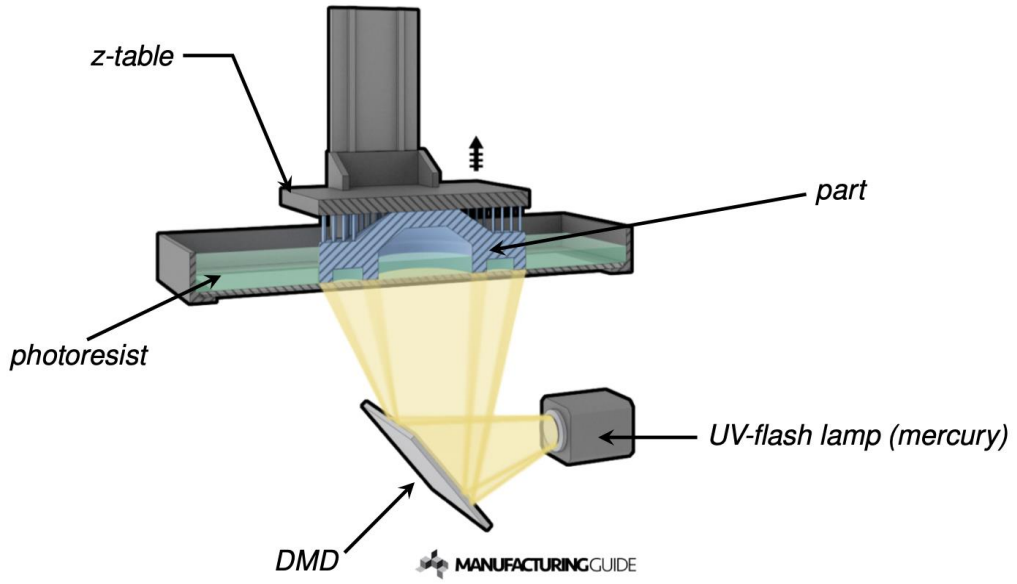
Mirrors project layer geometry onto resin.

↓

Layers cured simultaneously and adhere.

↓

Layers are added until object formed.



Credit: Chapter 2. Photopolymer based additive processes. *Brugger J. Moser C. Boillat, E.. 2024. URL:* https://moodle.epfl.ch/pluginfile.php/2836733/mod_resource/content/14/CHAP2_LiquidBasedProcesses_IMPRIMABLE.pdf

Dental Model

Credit: Dental 3d printing materials guide. Sprint Ray, November 21 2012. URL: https://sprintray.com/dental-3d-printing-materials-guide/.

4 Types Of Models

Diagnostic Model • Diagnostic analysis • Treatment planning	**Working Model** • Restoration field • Crown placement • Bridge fabrication
Study Model • For educational purpose • Training	**Orthodontic Model** • Tooth alignment • Intervention planning • Reference point

Wax-up

Credit: Y. Harichane. Le mock-up, un outil quotidien en esthétique dentaire. Den-tal Tribune, April 6 2016. URL: https://fr.dental-tribune.com/news/le-mock-up-un-outil-quotidien-en-esthetique-dentaire/.

A Moldable Model

How are they made ?

1. Take the impression
2. Make the plaster
3. Send it to a specialist
4. The specialist make a replica out of wax

Purpose

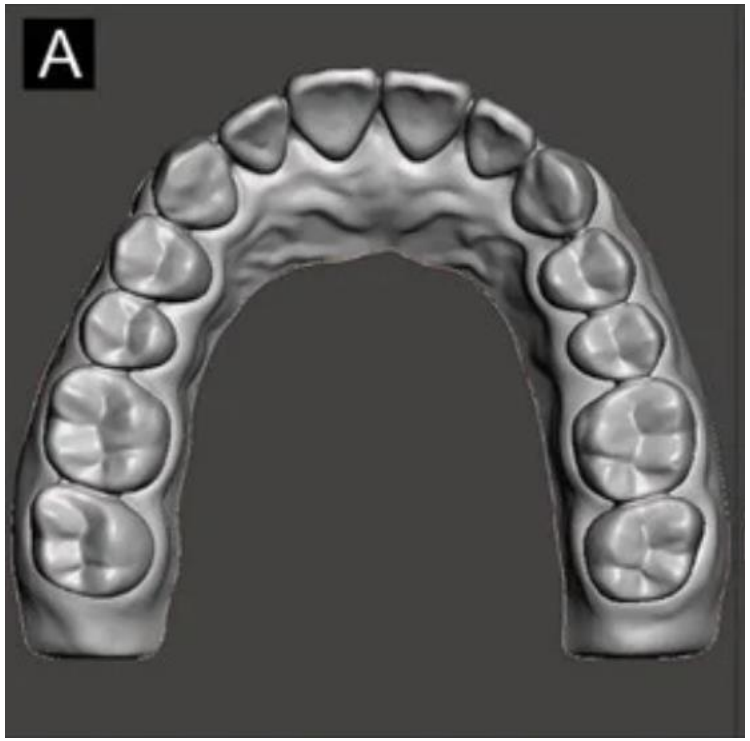
- Test and make adjustments
- Visualize the final restoration

Drawbacks

- Variable accuracy
- Fragile and prone to deformation
- Time-consuming and expensive to produce
- Risk of loss or damage during transportation between specialist and dentist

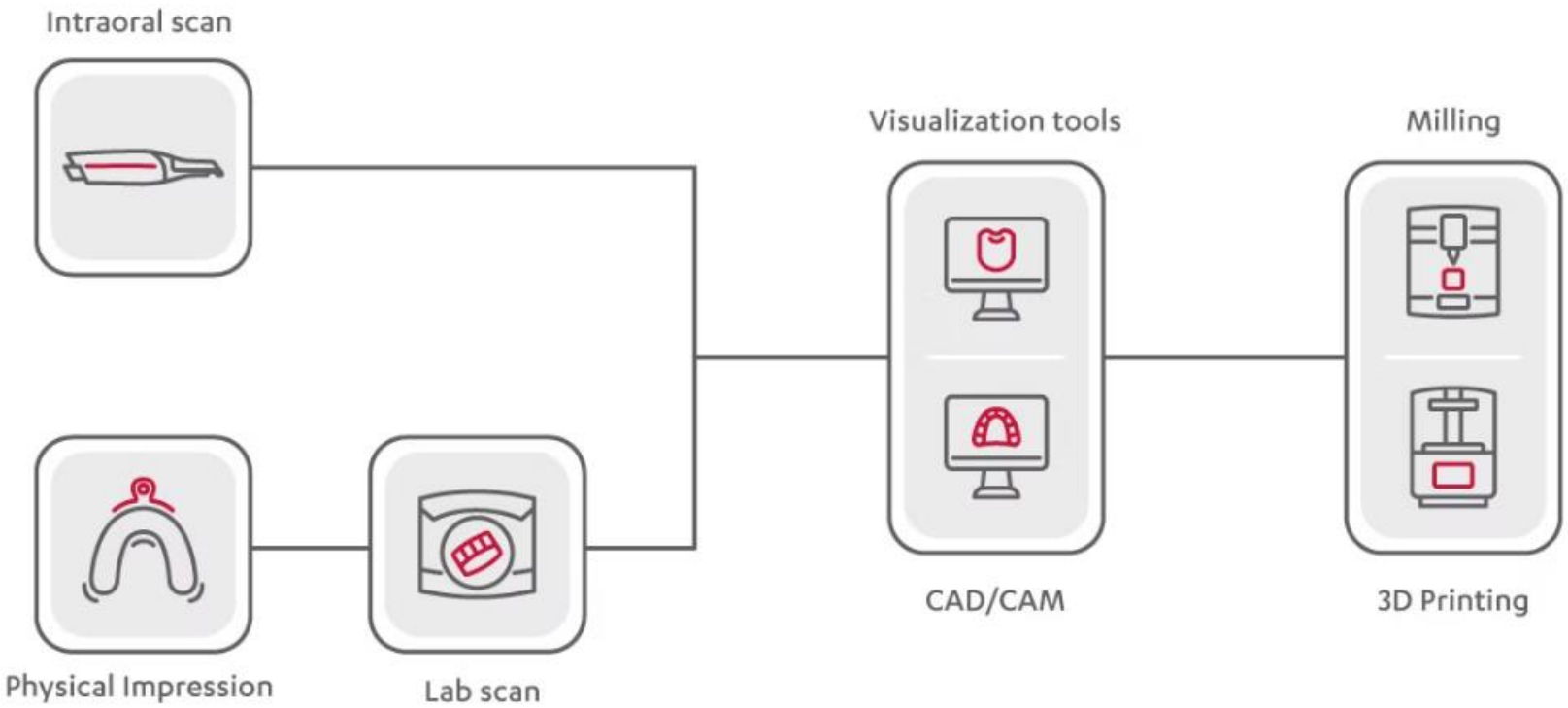
Digital Wax-up

Credit: Dr. Bharat Katarmal, How An Intra-oral Scanner works? https://www.drkatarmal.com/2014/11/how-intra-oral-scanner-works.html



Credit: Seung-Ho Shin, et al, 2020 Evaluation of the 3d printing accuracy of a dental model according to its internal structure and cross-arch plate design: An in vitro study.

Digital Wax-Up Process



Credit: What are digital impressions and how do they work? 3shape. URL: https://www.3shape.com/en/digital-dentistry/digital-impressions.

3D printing Result

Credit: Dental 3d printing materials guide. Sprint Ray, November 21 2012. URL: https://sprintray.com/dental-3d-printing-materials-guide/.

Advantages

- Quick to manufacture
- More confortable for the patient
- Very accurate
- Easy to make multiple options
- Cost effective

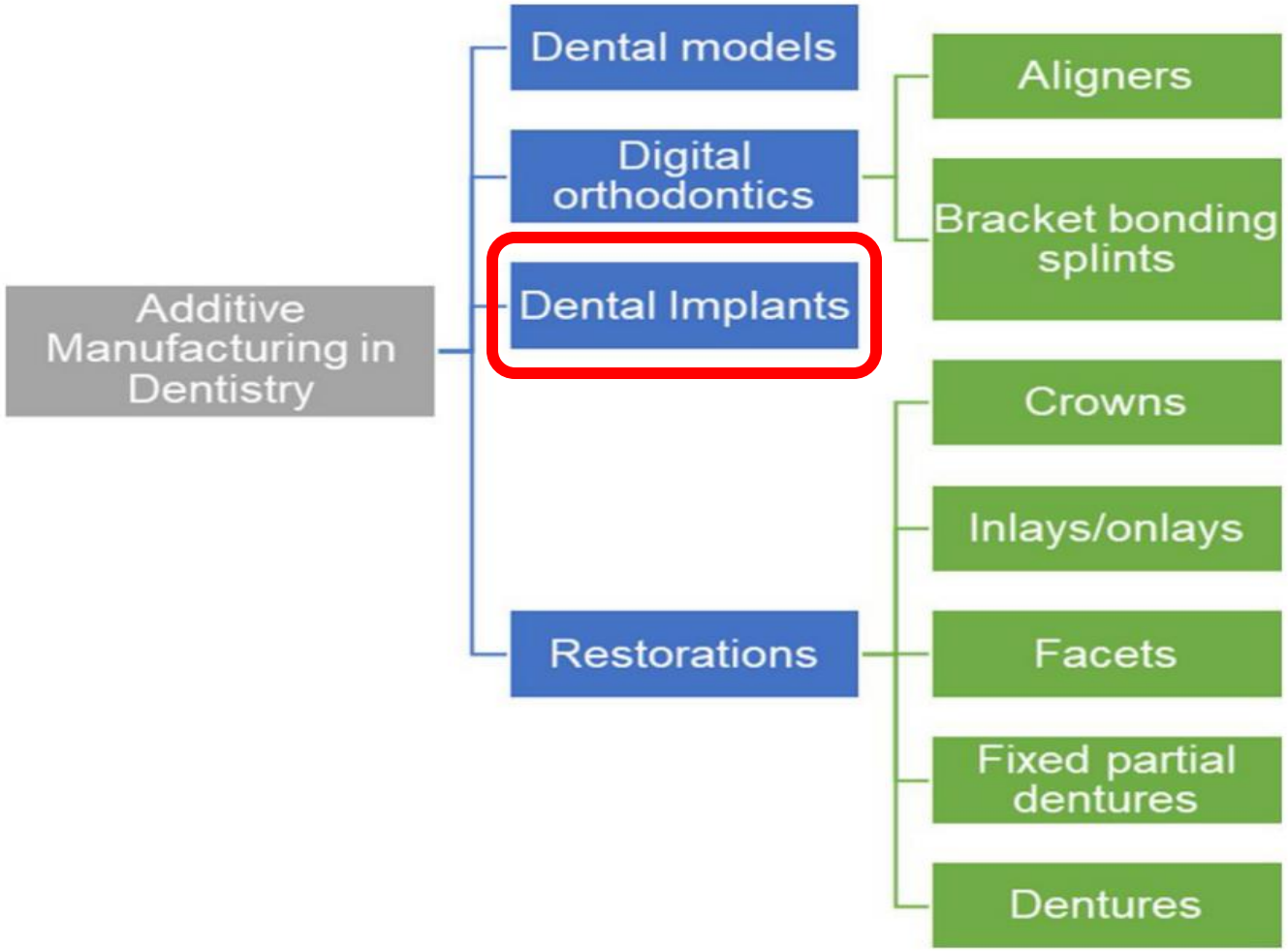
Disadvantages

- Lot of new equipments to acquire
- Change his procedure
- New staff to hire or to train

Dental Implantology

Credit: Comprehensive Guide to Molar Tooth Implants: https://www.casasadobesdentistry.com/the-complete-guide-to-molar-tooth-implant-surgery

AM in Dental Implantology



Key AM technologies

SLA, DLP, SLM, and EBM

Summary

- AM technologies
- Applications in surgery
- Applications in restoration
- Benefits and future directions

Credit: Additive manufacturing of ceramics for dental applications: A review. Raquel Sofia Cardoso Galante. April 2019. Dental Materials, https://doi.org/10.1016/j.dental.2019.02.026.

SLA and DLP in Dental Implantology

Role of SLA and DLP in fabricating customized surgical guides

Benefits

- Accuracy
- Pre-planned implant placement
- Reduced risks

Credit: *Digital Treatment Planning and Surgical Guides 2024.*
URL: https://glidewelldental.com/solutions/implant-solutions/digital-treatment-planning/surgical-guides-with-digital-treatment-planning

SLM and EBM: Building Titanium Frameworks

Credit: cytoflex-titanium-mesh-m4-100, 2024
URL: https://www.bonegrafting.com/products/cytoflex-titanium-mesh-m4-100

Summary

- Use in creating custom titanium meshes for GBR.
- Precision in designing pore size and shape for bone integration.

SLM and EBM for Implant Frameworks

- Strong, corrosion-resistant titanium structures for implants
- Stability and long-term functionality

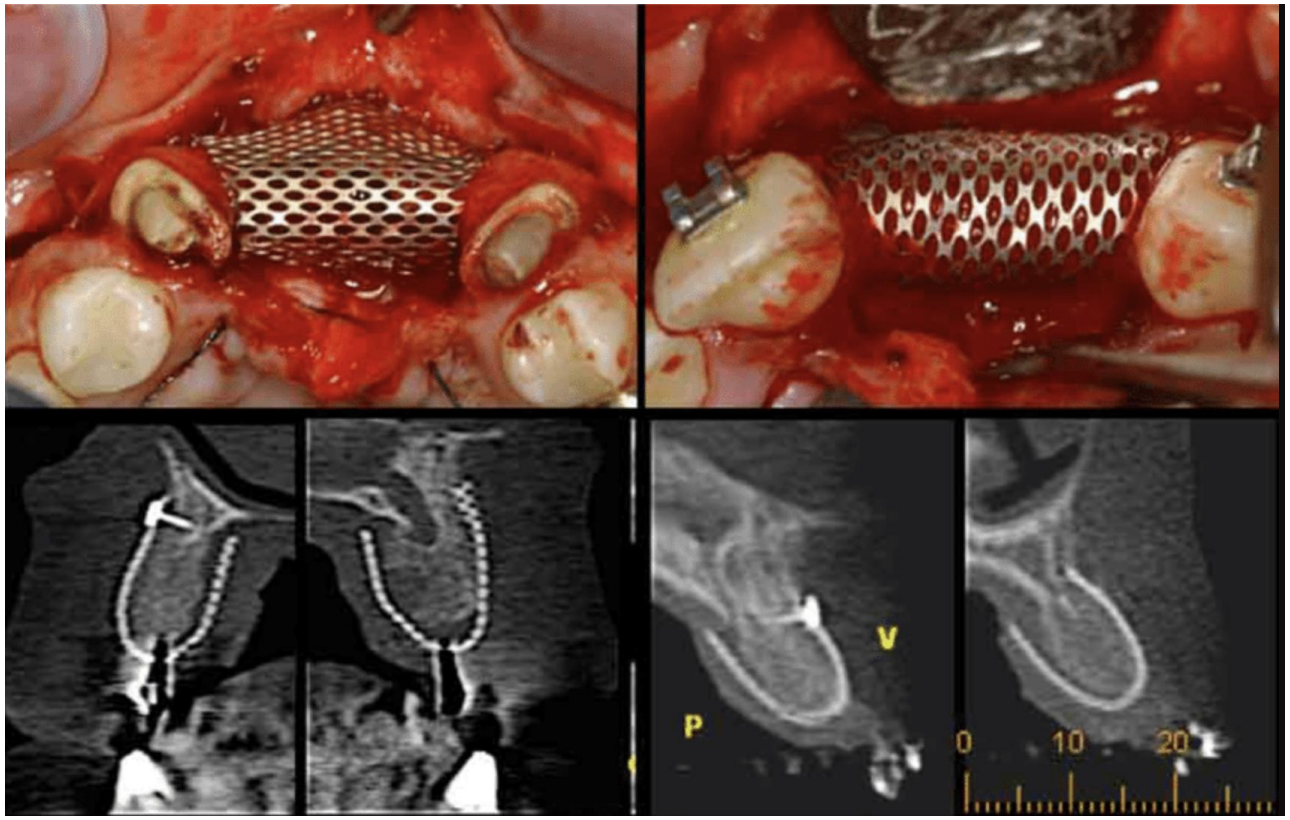
Credit: Titanium Partial Denture Frameworks, 2024
URL: https://stomadentlab.com/titanium-partial-denture-frameworks/

Surgical Guides

- How SLA and DLP enhance surgical precision
- Importance of customized guides in minimizing errors

Credit: *Digital Treatment Planning and Surgical Guides 2024.*
URL: https://glidewelldental.com/solutions/implant-solutions/digital-treatment-planning/surgical-guides-with-digital-treatment-planning

Titanium Meshes for GBR



Benefits of SLM and EBM in GBR fortreating complex bone defects

Credit: Bone augmentation of the atrophic anterior maxilla for dental implants using rhBMP-2 and titanium mesh: Histological and tomographic analysis. International journal of oral and maxillofacial surgery 2015. URL: https://www.researchgate.net/publication/280629405_Bone_augmentation_of_the_atrophic_anterior_maxilla_for_dental_implants_using_rhBMP-2_and_titanium_mesh_Histological_and_tomographic_analysis

Custom Impression Trays

- SLA and DLP in creating precise trays for accurate impressions
- Contribution to improved comfort and fit for restorations

Credit: *Denture Trays, 2024. URL:* https://goodfit.com/shop/denture-trays-individual-trays/

Prosthetic Frameworks

- SLM and EBM frameworks providing durable and functional support
- Reduced waste for cost and environmental benefits

Credit: MALO CLINIC study: Early indications for positive outcomes using PEEK-based JUVORA™ dental prosthetics*, January 30th 2019.*
URL: https://invibio.com/en/news/2019/early-indications-for-positive-outcomes

Benefits of Additive Manufacturing

Unparalled customization & precision

Signficantly reduces errors

Highly efficient

Future Directions in AM

- Faster printing technologies
- AI-driven workflow
- Automated customization

Credit: *The Ins and Outs of Root Canal, April 7th 2015 URL:* https://celinafamilydentistry.com/blog/2015/04/the-ins-and-outs-of-root-canal-therapy/

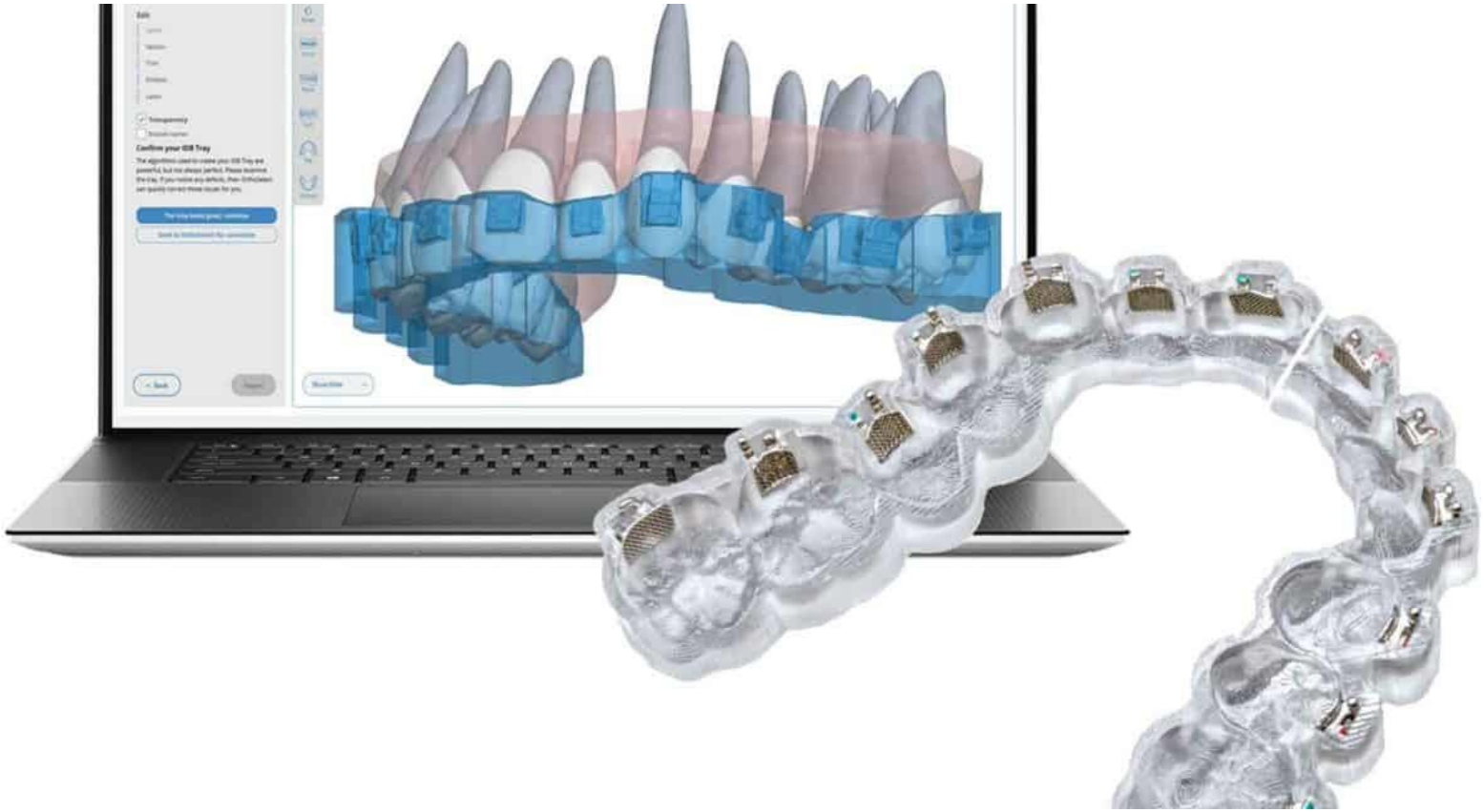
Key Takeaways

- Technologies: SLA, DLP, SLM, and EBM.
- Applications in surgery and restoration.
- Benefits of AM in improving outcomes.

" Dental implantology is no longer just about milling. Technological leaps in additive manufacturing have hastened both the pace at which dental clinicians can provide implant treatment and the extent to which they can personalise it. "

- Anisha Hall Hoppe, Dental Tribune International, 29 Sep 2023

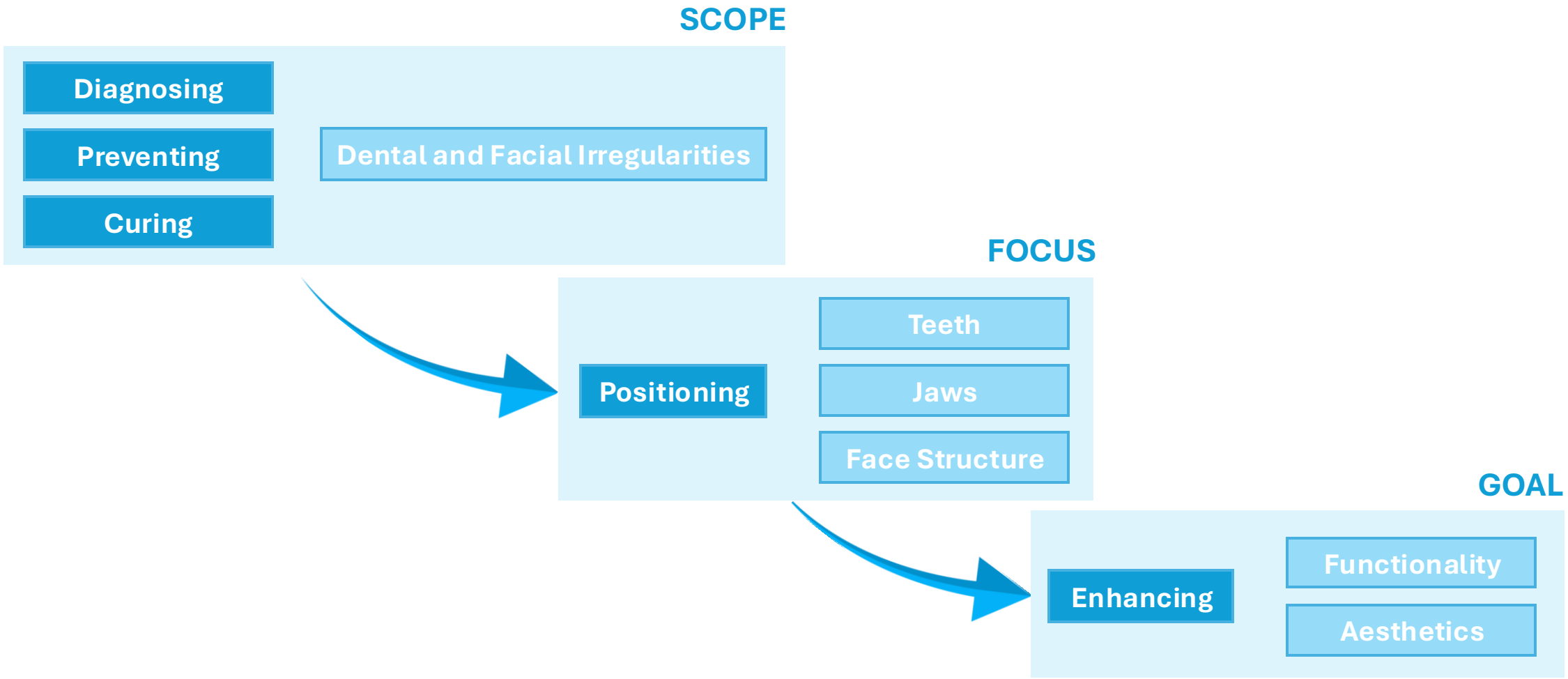
Digital Orthodontics



Credit: OrthoSelect Announces Major Advances in Digital Bracket Placement with the Release of DIBS AI 7.0. American Fork, May 10, 2022. URL: https://orthopracticeus.com/industry-news/orthoselect-announces-major-advances-in-digital-bracket-placement-with-the-release-of-dibs-ai-7-0/

Yara Sabbagha

Orthodontics



Credit: A. Mandal. What is orthodontics? News Medical Life Sciences, January 20 2023. URL: https://www.news-medical.net/health/What-is-Orthodontics.aspx.

Digital Orthodontics

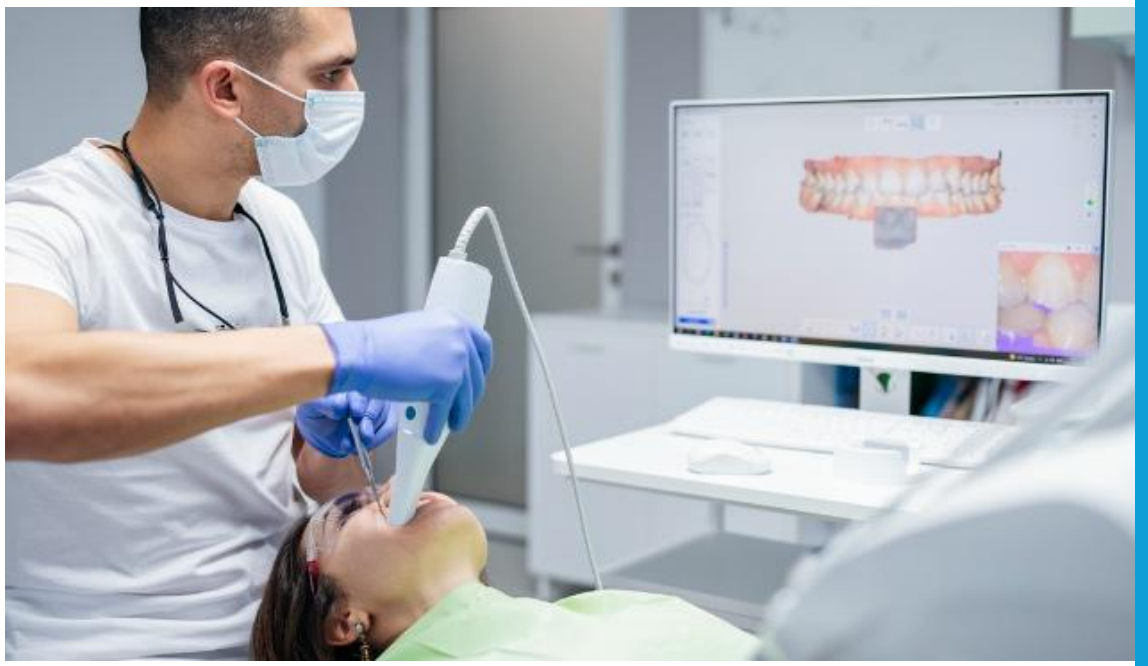
3D Imaging

Digital Scanners

Modelling Software

Benefits

Higher-quality models
More detailed and precise models
More personalized treatments
Enhanced patient comfort



Credit: Digital Orthodontics - The Future of Precision and Efficiency. November 29, 2023. URL: https://www.theorthodontists.com.au/blog/digital-orthodontics-the-future-of-precision-and-efficiency

Credit: N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

Digital Orthodontics

Additive Manufacturing

Benefits

Highly customization and accuracy
Smaller, more complex items
Minimal waste
Lower volumes necessary
Faster production time

Credit:
D. Igor. Additive manufacturing in orthodontics. ResearchGate, April 2019. URL: https://www.researchgate.net/publication/332906251_Additive_manufacturing_in_orthodontics.
3D Print Clear Aligner Models. URL: https://sprintray.com/digital-dentistry/clear-aligners/
Braces On Demand!. 2020. URL: https://www.3dhub.gr/braces-on-demand/

AM for Orthodontic Aligners

Orthodontic Aligners

- Aesthetic and comfortable alternative to braces
- Effective malocclusion treatment
- Allow enhanced oral hygiene during treatment

Use of Additive Manufacturing

- Fast
- Efficient
- Ecological
- Precise
- Consistent
- Customizable

Credit:

Dimitri Mantazis. Dental Aligners: Everything You Need to Know. Hove Dental Clinic, December 21, 2022. URL: https://www.hovedentalclinic.co.uk/blog/aligners/.

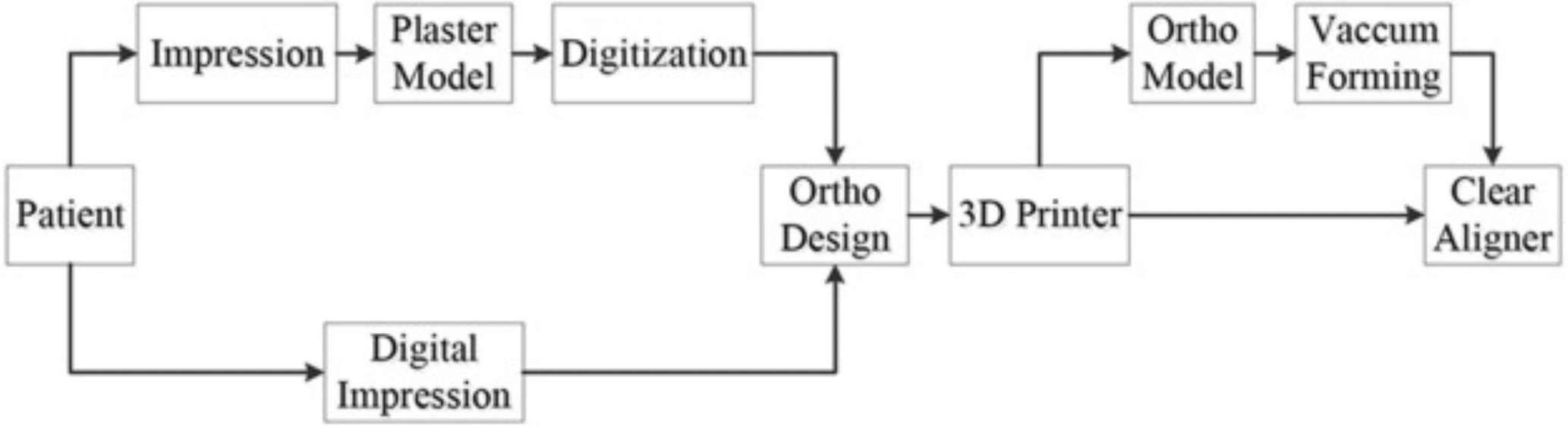
A. Pugalendhi. Novel fabrication method for clear and hard tooth aligner through additive manufacturing technology: A pilot study. ScienceDirect, June 30 2020. URL: https://www.sciencedirect.com/science/article/pii/S2214785319342476.

G. Tartaglia. Direct 3d printing of clear orthodontic aligners: Current state and future possibilities. MDPI, April 5 2021. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC8038630/pdf/materials-14-01799.pdf.

N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

AM for Orthodontic Aligners

Production Workflow



Credit:

A. Pugalendhi. Novel fabrication method for clear and hard tooth aligner through additive manufacturing technology: A pilot study. ScienceDirect, June 30 2020. URL: https://www.sciencedirect.com/science/article/pii/S2214785319342476.

G. Tartaglia. Direct 3d printing of clear orthodontic aligners: Current state and future possibilities. MDPI, April 5 2021. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC8038630/pdf/materials-14-01799.pdf.

N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

AM for Orthodontic Aligners

	Thermoformed Aligners	3D-Printed Aligners
	Fabricated by molding thermoplastic sheets (e.g., polyurethane, PETG).	Produced with SLA or DLP directly from photopolymer resins (e.g., Dental LT®).
Advantages	• Flexible, transparent	• Superior accuracy, consistent thickness • Customizable force application • Higher mechanical strength and elastic recovery
Inconvenients	• Heat-induced inconsistencies in thickness and properties • Prone to deformation in oral environments	• Cytotoxicity risks with uncured resins • Requires precise post-curing protocols

Credit:
A. Pugalendhi. Novel fabrication method for clear and hard tooth aligner through additive manufacturing technology: A pilot study. ScienceDirect, June 30 2020. URL: https://www.sciencedirect.com/science/article/pii/S2214785319342476.
G. Tartaglia. Direct 3d printing of clear orthodontic aligners: Current state and future possibilities. MDPI, April 5 2021. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC8038630/pdf/materials-14-01799.pdf.
N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

AM for Orthodontic Aligners

Material Considerations

Material selection is critical for long-term aligner performance

Thermoformed Materials

- Flexible and transparent but prone to deformation

3D-Printed Resins

- Higher load resistance and durability
- Biocompatibility challenges require further research

Credit:
A. Pugalendhi. Novel fabrication method for clear and hard tooth aligner through additive manufacturing technology: A pilot study. ScienceDirect, June 30 2020. URL: https://www.sciencedirect.com/science/article/pii/S2214785319342476.
G. Tartaglia. Direct 3d printing of clear orthodontic aligners: Current state and future possibilities. MDPI, April 5 2021. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC8038630/pdf/materials-14-01799.pdf.
N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

AM for Orthodontic Brackets

Orthodontic Brackets

- Small orthodontic devices bonded to teeth.
- Hold archwires to apply corrective forces.
- Essential for aligning and straightening teeth.

Use of Additive Manufacturing

- Personalization
- Precision
- Efficiency
- Speed

Credit:

8 Types of Orthodontic Brackets (How to Choose). URL: https://luxedentalcaremd.com/8-types-of-orthodontic-brackets

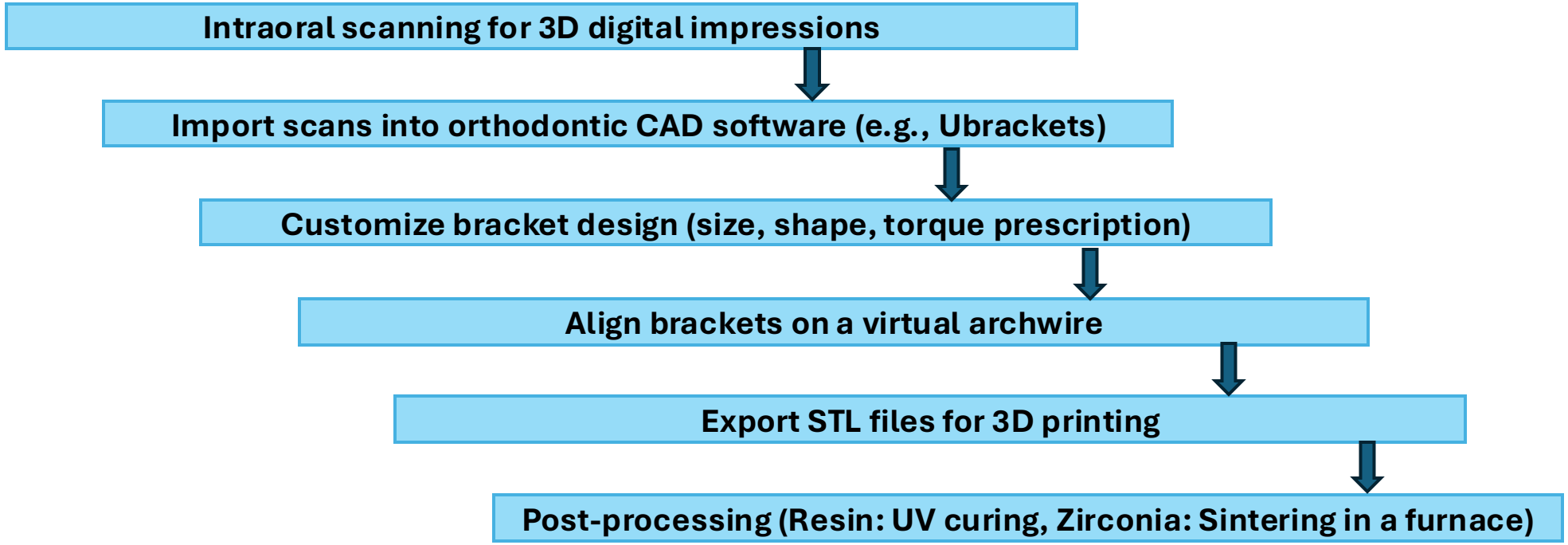
N. Panayi. In-house three-dimensional designing and printing customized brack- ets. ScienceDirect, November 30 2022. URL: https://www.sciencedirect.com/science/article/pii/S2212443822000625?ref=cra_js_challenge&fr=RR-1.

N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

S. Papageorgiou. New aesthetic in-house 3d-printed brackets: proof of concept and fundamental mechanical properties. SpringerOpen, 2022. URL: https://progressinorthodontics.springeropen.com/articles/10.1186/s40510-022-00400-z.

AM for Orthodontic Brackets

Production Workflow



Credit:

N. Panayi. In-house three-dimensional designing and printing customized brack- ets. ScienceDirect, November 30 2022. URL: https://www.sciencedirect.com/science/article/pii/S2212443822000625?ref=cra_js_challenge&fr=RR-1.

N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.

S. Papageorgiou. New aesthetic in-house 3d-printed brackets: proof of concept and fundamental mechanical properties. SpringerOpen, 2022. URL: https://progressinorthodontics.springeropen.com/articles/10.1186/s40510-022-00400-z.

AM for Orthodontic Brackets

Resin-Based Brackets

Manufacturing

- SLA or DLP printers
- Layers built from hybrid ceramic photopolymer
- UV light for curing

Advantages

- Lightweight, customizable
- Aesthetic, tooth-colored
- Affordable

Inconvenients

- Lower hardness, durability
- Curing precision affects mechanical properties

Credit:
N. Panayi. In-house three-dimensional designing and printing customized brack- ets. ScienceDirect, November 30 2022. URL: https://www.sciencedirect.com/science/article/pii/S2212443822000625?ref=cra_js_challenge&fr=RR-1.
N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.
S. Papageorgiou. New aesthetic in-house 3d-printed brackets: proof of concept and fundamental mechanical properties. SpringerOpen, 2022. URL: https://progressinorthodontics.springeropen.com/articles/10.1186/s40510-022-00400-z.

AM for Orthodontic Brackets

Zirconia-Based Brackets

Manufacturing

- Slurry-based 3D printing
- Sintering creates dense, durable structures

Advantages

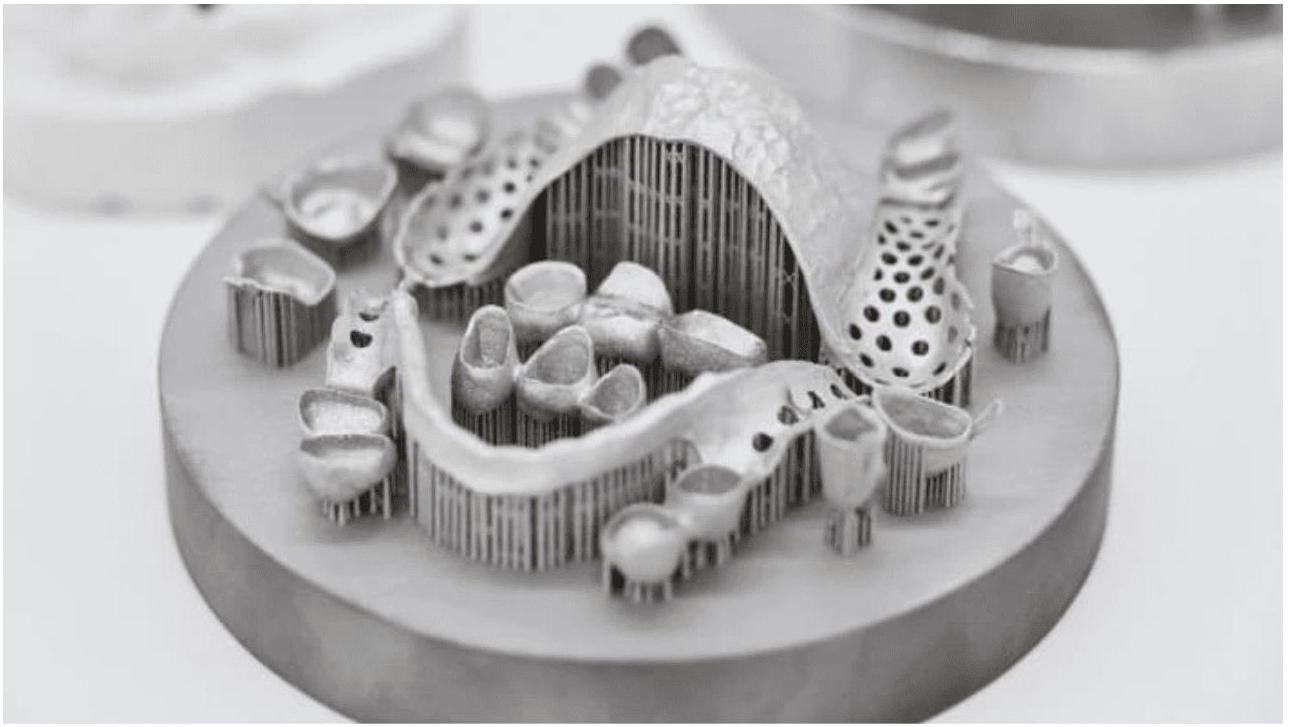
- High strength and wear resistance
- Translucent and enamel-like aesthetics

Inconvenients

- Complex and long process (sintering)
- Requires additional equipment and expertise

Credit:
N. Panayi. In-house three-dimensional designing and printing customized brack- ets. ScienceDirect, November 30 2022. URL: https://www.sciencedirect.com/science/article/pii/S2212443822000625?ref=cra_js_challenge&fr=RR-1.
N. Panayi. Digital orthodontics: Present and future. ScienceDirect, February 13 2024. URL: https://www.sciencedirect.com/science/article/pii/S2666430523001528.
S. Papageorgiou. New aesthetic in-house 3d-printed brackets: proof of concept and fundamental mechanical properties. SpringerOpen, 2022. URL: https://progressinorthodontics.springeropen.com/articles/10.1186/s40510-022-00400-z.

Restorative dentistry



Credit :
Haresh Savani, Role of Additive Manufacturing process in Dentistry, Advance Dental Export, November 22, 2022
Url: https://advancedentalexport.com/role-of-additive-manufacturing-process-in-dentistry-advance-dental-export/

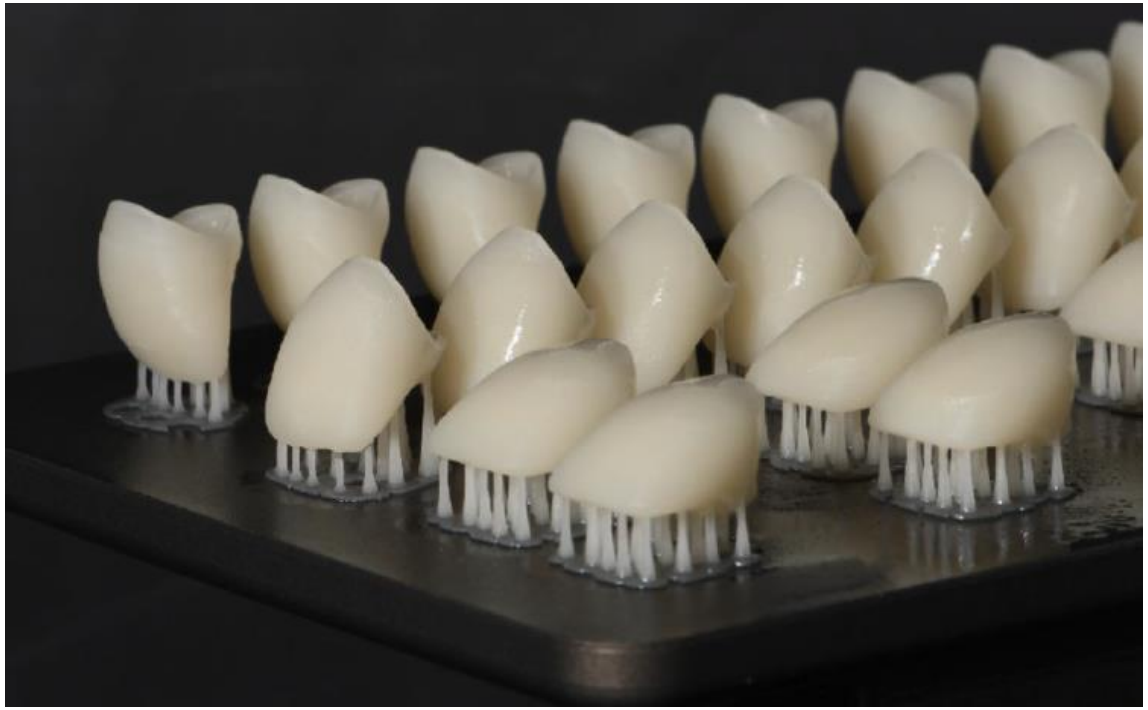
Michaela Rosinska

Restorations - Overview

- Replacing teeth
- Restoring oral health
- Indirect restorations
- Temporary restorations

Credit :
Newnan dental studio, Restorative dentistry
URL : https://newnandentalstudio.com/restorative-dentistry

Crowns



- SLM, SLS, DLP

- Metal-ceramics
- Resins

Credit :

Yong-Kyu Kim, Jung-Suk Han, and Hyung-In Yoon. Evaluation of intaglio surface trueness, wear, and fracture resistance of zirconia crown under simulated mastication: A comparative analysis between subtractive and additive manufacturing. The Journal of Advanced Prosthodontics, 2022. doi:10.4047/jap.2022.14.2.122

Nuria Mart´ın-Ortega, Alessandro Sallorenzo, Javier Casaj´us, Alberto Cervera, Marta Revilla-Léon, and Miguel Gómez-Polo. Fracture resistance of additive manufactured and milled implant-supported interim crowns. The Journal of Prosthetic Dentistry, February 2022. doi:10.1016/j.prosdent.2020.11.017

Gülce ¸Cakmak, Mustafa Borga Donmez, Alfonso Rodrigues Cuellar, ¸Ci˘gdem Kahveci, Martin Schimmel, and Burak Yilmaz. Additive or subtractive manufacturing of crown patterns used for pressing or casting: A trueness analysis. Journal of Dentistry, September 2022. doi:10.1016/j.jdent.2022.104221.25

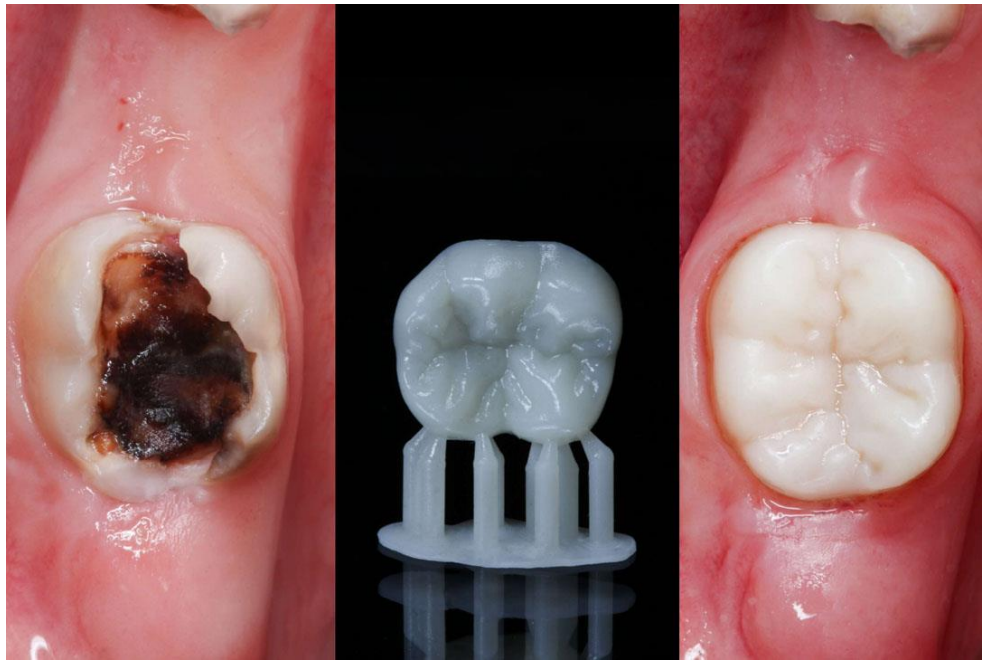
Bridges

- Replacing multiple teeth
- Minimal surgery
- Lost-wax casting

Credit : Dental Bridges, Sandown Dental Practice, https://www.sandowndentalpractice.co.uk/dental-bridges/

Credit :
Tsanka Dikova and Tihomir Vasilev. Bending fracture of co-cr dental bridges, produced by additive technologies: Simulation analysis and test. Engineering Fracture Mechanics, 2019. doi:10.1016/j.engfracmech.2019.106583

Inlays and Onlays



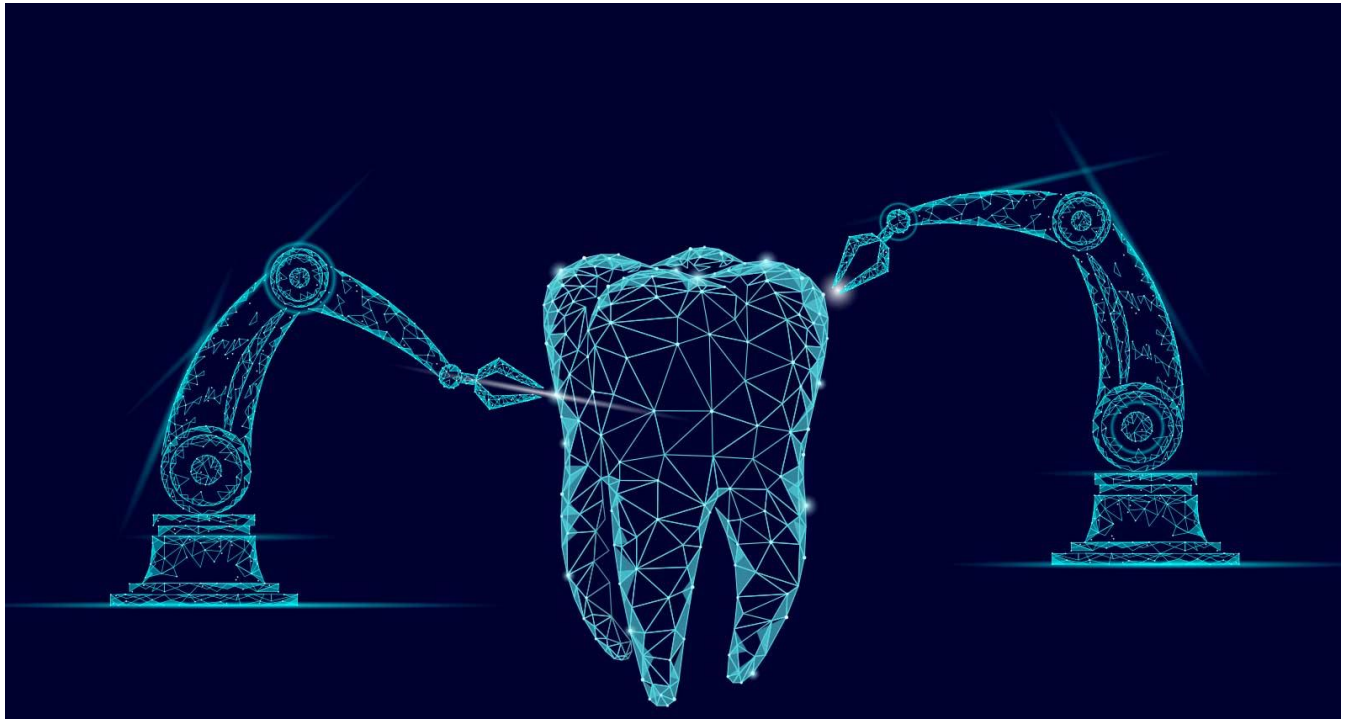
Credit:
3D-Printed indirect permanent restoration, Dr Hüseyin Şimşek. URL : https://www.styleitaliano.org/3d-printed-indirect-permanent-restoration/

- Wax patterns
- Small cavities

Credit:
M. Revilla-Leon. Marginal and internal gap of handmade, milled and 3d printed additive manufactured patterns for pressed lithium disilicate onlay restorations. European Journal of Prosthodontics and Restorative Dentistry, 26:31–38, 2018. doi:10.1922/EJPRD_01733RevillaLeon08

Advantages

- Fabrication time
- Precision
- Price
- Efficiency



Credit: 3D Printing in Dentistry: Challenges and Solutions, Aranca, December 7 2022, URL: https://www.aranca.com/knowledge-library/articles/ip-research/3d-printing-in-dentistry-challenges-and-solutions

Challenges

- Material compatibility
- Equipment cost
- Training

Credit: Revolutionary Dental Care: 3D Printing in Periodontics, November 4 2024, URL: https://us.idyllic.app/gen/high-tech-dental-clinic-355853?highlighted=1262676

Future development

Credit: Shantanu Jaradi. 3 Technologies that will shape the future of dentistry. ET Health World, March 7 2022. URL: https://health.economictimes.indiatimes.com/news/industry/3-technologies-that-will-shape-the-future-of-dentistry/90041181

Yara, Michaela

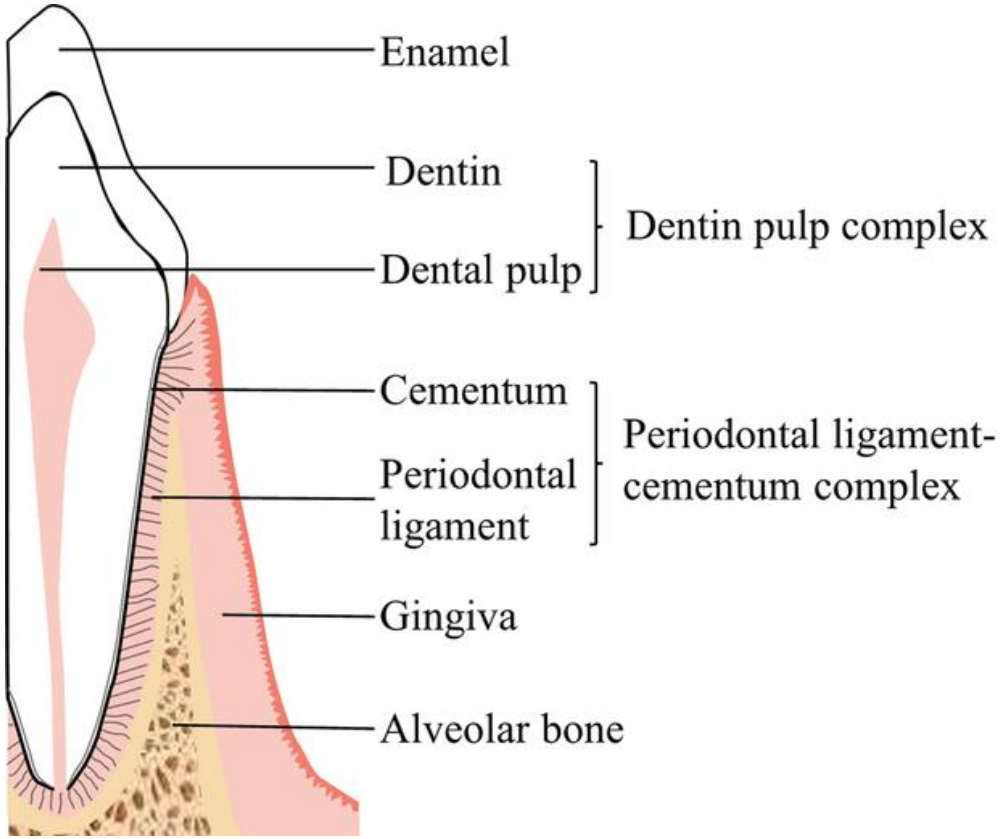
AM for tissue regeneration

Hard tissues

- Enamel
- Dentin
- Alveolar bone

Soft tissues

- Dental pulp
- Periodontal ligament
- Gingiva

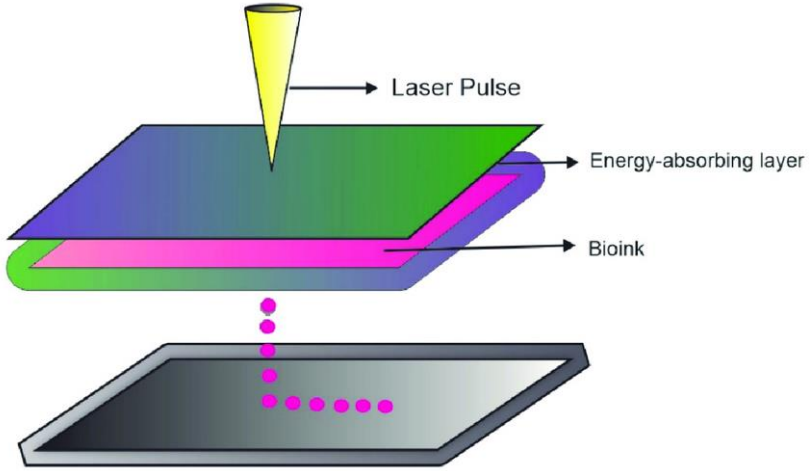


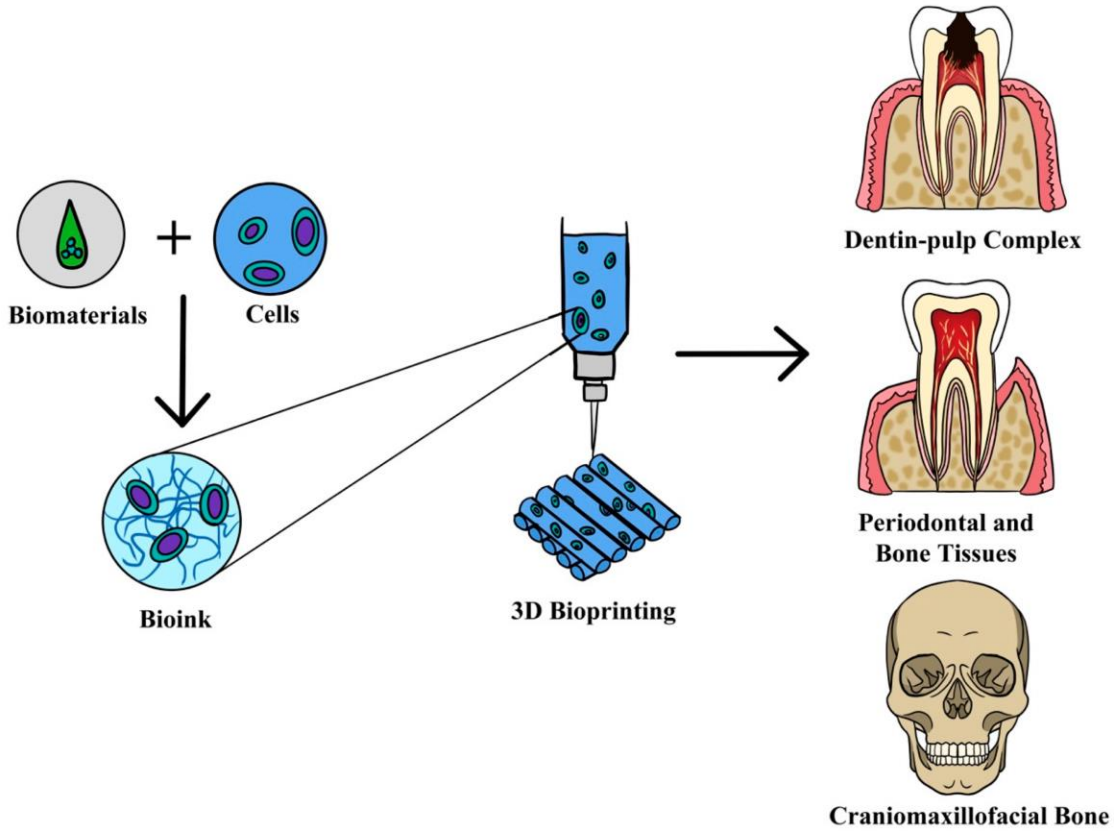
Credit:
Jie Zhao, Ying-Hui Zhou, Ya-Qing Zhao, Zheng-Rong Gao, Ze-Yue Ouyang, Qin Ye, Qiong Liu, and et al. Oral cavity-derived stem cells and preclinical models of jaw-bone defects for bone tissue engineering. Stem Cell Research & Therapy, 2023. doi:10.1186/s13287-023-03265-z

AM for tissue regeneration

Applications

- Scaffolds
- Vascularization
- Periodontal regeneration





Credit:
Lima, Tainara De P. L., Caio Augusto D. A. Canelas, Viktor O. C. Concha, Fernando A. M. Da Costa, et Marcele F. Passos. « 3D Bioprinting Technology and Hydrogels Used in the Process ». Journal of Functional Biomaterials 13, nº 4 (3 novembre 2022): 214. https://doi.org/10.3390/jfb13040214

Credit:
Mohd, N., Razali, M., Fauzi, M. B., & Abu Kasim, N. H. (2023). In Vitro and In Vivo Biological Assessments of 3D-Bioprinted Scaffolds for Dental Applications. International Journal of Molecular Sciences, 24(16), 12881. https://doi.org/10.3390/ijms241612881

4D Printing

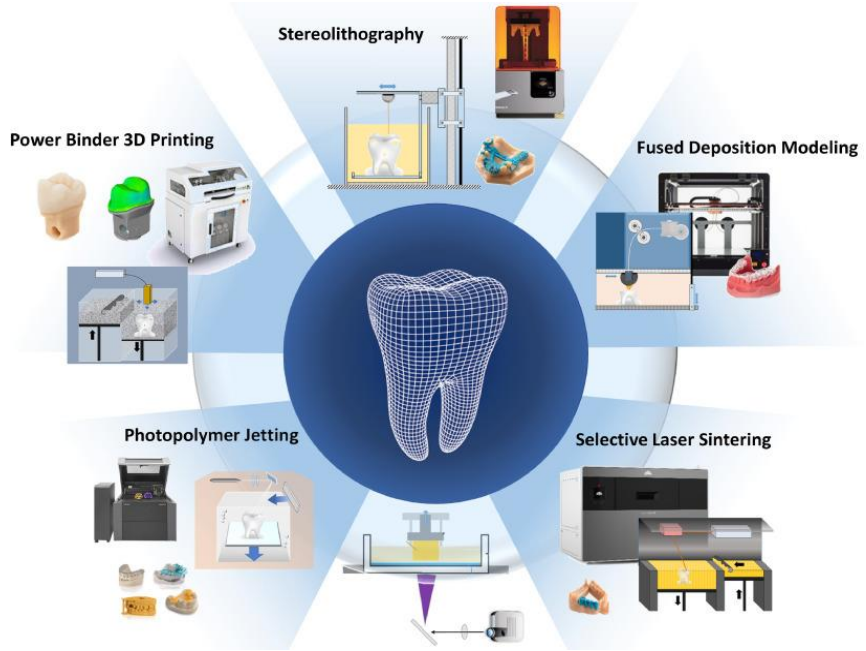
Introduction

- Combines 3D printing with time as the fourth dimension.
- Creates dynamic materials that adapt to external stimuli (e.g., temperature, moisture, pH).
- Enables personalized, adaptive dental solutions.

	3D printing	4D printing
Technique	Additive manufacturing technology with static materials	Additive manufacturing technology with smart materials
Dimensions	Three dimensions	Four dimensions (time is added)
Reaction to time and stimulus	Materials do not respond to time and stimulus	Smart materials transform after being subjected to external stimulus
Built process	Here, one layer is printed, and the next second layer is printed above the first layer	It is the same as 3D printing but with the additional advantage of using smart materials
Materials	Resins, ceramics, metals, polymers.	Smart, multi-materials
Flexibility	Stiff, firm, static materials are formed	Dynamic, flexible materials
Applications	Surgical guides, aligners, individual impression trays, splints, models, wax-up framework, crowns and bridges, implants, etc	Restorative materials, individual-specific implants, dentures, splints, local drug delivery systems, root canal filling materials, ridge-specific dentures, etc

Credit:
Y. Perambudhuru. Application of 4d printing in dentistry: A narrative review. National Library of Medicine, March 2024. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC11252150/.

4D Printing



Benefits

- Dynamic adaptability, improved functionality and treatment outcome
- Improved fit and reliability of appliance, limiting risk of complications
- Restorative materials with superior mechanical properties (e.g. elasticity, strength, durability and biocompatibility)
- Tissue repair and regeneration

Credit:
D. Khorsandi. 3D and 4D printing in dentistry and maxillofacial surgery: Printing techniques, materials, and applications. Acta Biomaterialia, February 2021. https://doi.org/10.1016/j.actbio.2020.12.044.

Conclusion

AM for the dental industry offers major improvements:

- Greater precision
- Lower cost
- Faster production

4D printing technology is a promising technique for personalized dental care.


Thank you for your attention!