# Overview of FDM 3D Printing in Health Care

| *FDM 3D Printing in HC* | *Core Principle* | *Key Components / Variables* | *Technical Considerations* | *Clinical / Practical Relevance* |
|---|---|---|---|---|
| ***FDM Foundations*** | Additive manufacturing builds objects layer by layer from a digital model | CAD models, MRI/CT imaging, STL files | Model quality determines final accuracy | Enables patient-specific solutions and anatomical customization |
| ***3D Printing Techniques*** | Different energy/material deposition methods | Extrusion, Sintering, SLA, FDM | Resolution, material compatibility, equipment cost | Selection depends on precision needs and application context |
| ***Extrusion System*** | Thermoplastic filament is melted and deposited through a nozzle | Filament (PLA, ABS, PETG, TPU), Hot End, Nozzle (e.g., 0.4 mm), Direct Drive / Bowden | Nozzle diameter determines resolution and layer height (≤70–80% of nozzle size) | Determines structural integrity and suitability for orthoses, guides, simulators |
| ***Kinematics & Motion Control*** | Controlled movement in Cartesian coordinates | X–Y–Z axes, Stepper motors, Belts, Lead screws | Open-loop control; mechanical misalignment may cause layer shifting | Critical for dimensional accuracy in surgical guides and patient-specific devices |
| ***Thermal Management*** | Controlled heating and cooling ensures bonding | Heated bed (PLA: 50–60°C; ABS: 100–120°C), Cooling fans | Balance between extrusion temperature and cooling rate | Prevents warping and ensures structural stability |
| ***Materials in FDM*** | Mechanical and biological performance depends on material choice | PLA, ABS, PETG, TPU, PVA (supports) | Strength, flexibility, temperature resistance, support removal | Determines mechanical behavior and potential medical application |
| ***Digital Design & Optimization*** | Geometry created or modified before fabrication | CAD software, medical imaging, mesh inspection | Surface quality and model integrity essential | Prevents printing errors and improves clinical precision |
| ***Slicing & G-Code Generation*** | Digital model converted into machine instructions | STL file, Slicer software (e.g., Cura), G-Code | Correct printer selection prevents mechanical damage | Ensures safe and precise execution |
| ***Parameterization*** | Internal and external object characteristics are software-defined | Layer height, Speed, Infill density/pattern, Wall thickness | Trade-off between strength, time, and surface quality | Tailors' device resistance and weight |
| ***Execution & Fabrication*** | Layer-by-layer physical construction | G-Code transfer, First-layer adhesion, Skirt | Calibration and maintenance essential | Determines reproducibility and reliability |
| ***Post-Processing*** | Final refinement of printed object | Support removal, Acetone vapor, UV curing, Mechanical polishing | Material-dependent finishing techniques | Enhances durability, aesthetics, and functional performance |