PATIENT-SPECIFIC 3D DRILLING AIMER GENERATION FOR MANDIBULAR RAMUS FRACTURES

VYTAUTAS MAGNUS UNIVERSITY
Faculty of Informatics

AUTHORS: Vilius Šarkinas Eimantas Zaranka Monika Katilienė Romas Daugnora Jonas Domarkas

1 MOTIVATION

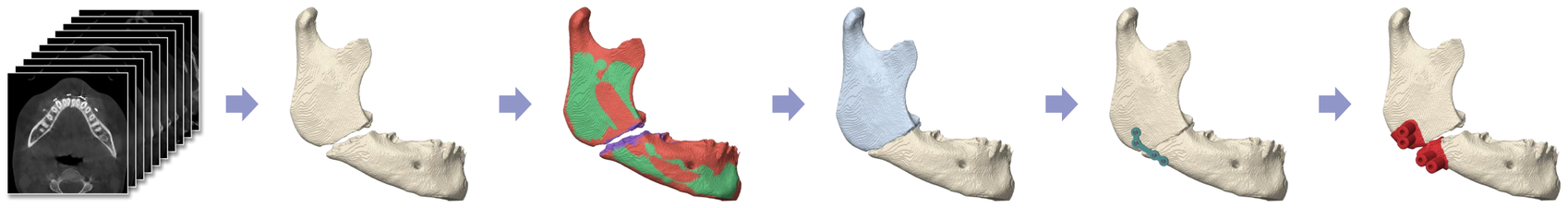
- Mandibular angle and ramus fractures are usually fixed with titanium miniplates; every screw hole is drilled through a narrow intra-oral access.
- A wrong drilling angle or position can injure the inferior alveolar nerve canal or tooth roots, or put a screw into the fracture line.
- Plate position is chosen by eye during surgery, and designing patient-specific drilling guides by hand in CAD is slow and needs an engineer.

2 GOALS

- Build an automatic pipeline from a patient CT scan (DICOM) to 3D-printable drilling aimers.
- Segment the bone into safe, risk and fracture zones and virtually reduce the fracture.
- Search for miniplate positions and rank them by fit, zone safety and biomechanics (FEA).
- Generate drilling aimers for the best plate and test them on 3D-printed bone models.

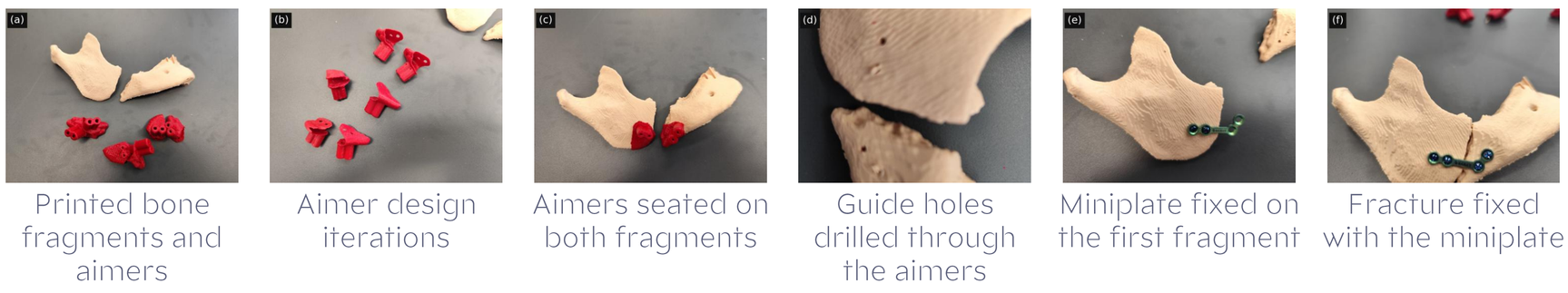
3 PIPELINE

1 CT SCAN → 2 BONE MODEL → 3 ZONE SEGMENTATION → 4 FRACTURE REDUCTION → 5 MINIPLATE PLANNING → 6 AIMER GENERATION



1 CT SCAN	2 BONE MODEL	3 ZONE SEGMENTATION	4 FRACTURE REDUCTION	5 MINIPLATE PLANNING	6 AIMER GENERATION
DICOM series → NIfTI volume (HU)	nnU-Net → mandible mesh, aligned to a reference bone	RandLA-Net point cloud: safe / risk / fracture zones	Fragments split and re-aligned (ICP)	Pose search → FEA → ranking; best plate and screws	Patient-specific drill guide on each fragment

4 3D-PRINTED AIMERS



(a)	(b)	(c)	(d)	(e)	(f)
Printed bone fragments and aimers	Aimer design iterations	Aimers seated on both fragments	Guide holes drilled through the aimers	Miniplate fixed on the first fragment	Fracture fixed with the miniplate

5 RESULTS

How the plate positions are compared

Metric	How it is computed	Plate 1	Plate 2	Plate 3
Plate fit RMSE, mm	RMS plate–bone distance	0.82	0.79	0.96
Safe-zone share, %	Bone under plate in safe zone	84.8	80.7	83.8
FEA: fracture motion, µm	Motion at the fracture	1.54	1.17	1.43
FEA: bone stress, MPa	Mean von Mises stress	0.32	0.32	0.37

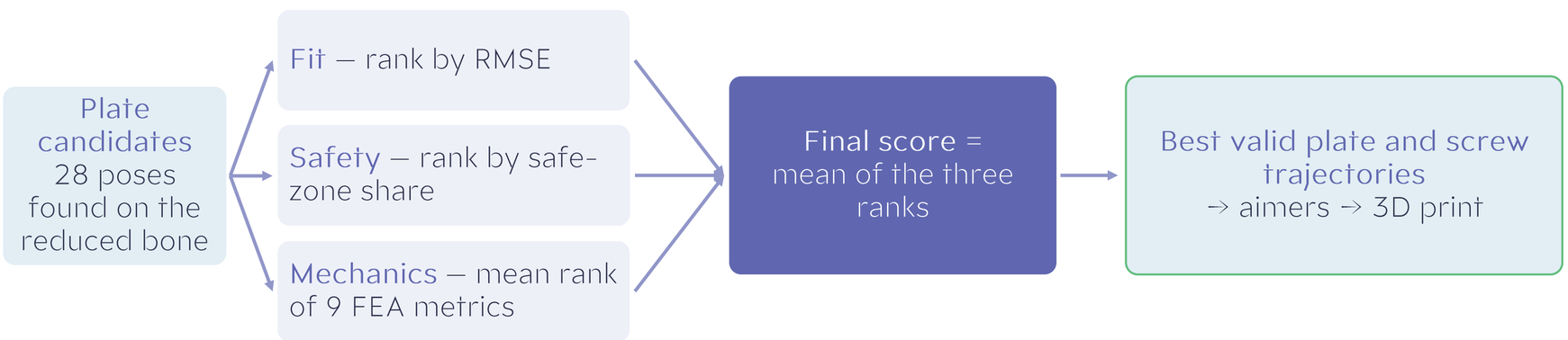
Only 2 of the 9 FEA metrics are shown; the other 7 (local motion, mean and maximum fracture-gap change, maximum, mean and RMS displacement, and maximum stress) are also included in the ranking.

Latency and memory

Stage	GPU, s	CPU, s	RAM, GB	VRAM, GB
CT import + nnU-Net	24–70	129–492	9.7	3.46
MAR (OSCNet+, optional)	20–101	181–940	1.85	0.53
Zone segm. (RandLA-Net)	5.3–11.6	71–165	2.8	0.8
Alignment + reconstruction	–	67	0.9	–
Plate search + FEA*	–	1032	3.2	–
Aimer generation	–	99	5.3	–

* Depends on the search space; timed run: 28 miniplate positions.

How the results are interpreted



6 CONCLUSIONS

- An integrated prototype connects CT processing, fracture reconstruction, plate and screw planning, and drilling guide generation.
- Candidate plate positions are ranked by fit, anatomical safety criteria and FEA.
- Demonstration on a patient case, including 3D printing and physical assembly, supports technical feasibility; broader testing and clinical validation remain necessary.

7 FUTURE PLANS

- Develop the segmentation model using annotated CT cases with more diverse fracture patterns and complexity levels.
- More plate types and fixation methods — two-plate fixation, placement along Champy's ideal osteosynthesis lines and automatic plate bending to the bone surface.
- Clinical validation together with maxillofacial surgeons.

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