JOHNS HOPKINS
WHITING SCHOOL
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Building a Workflow for Cooperatively Controlled Robotic Mandibular Surgery

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Project Summary

- Mandibular Surgery [1]
  - Used to correct overextended jaw or receding chin
- Cutting through the mandible has the risk of damaging the alveolar nerve [3]
- Our goal is to create a cooperative robotic workflow with virtual guidance
  - Reduces risk of harm
  - Improves accuracy

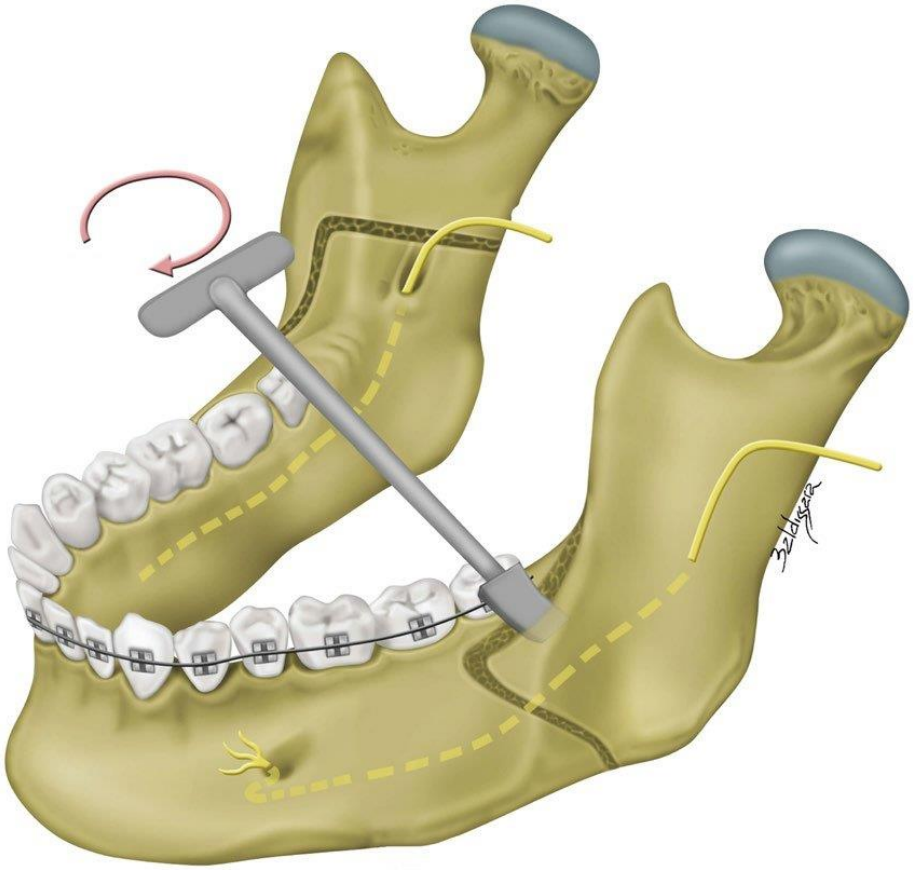


Image: [2]

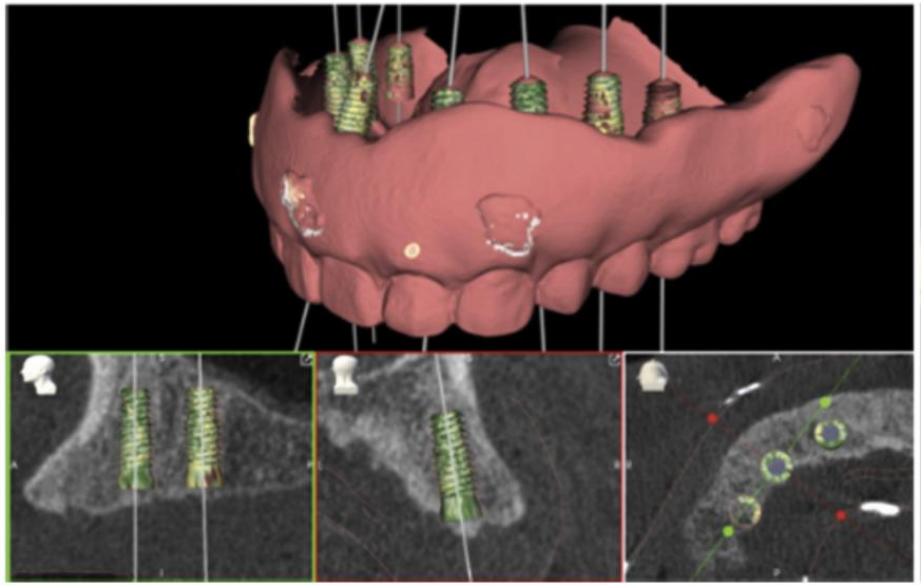
YOMI Dental Robot – Paper Selection

- Clinical study of the YOMI dental robot [4]
  - Cooperative robotic platform
  - Utilizes virtual guidance
  - Designed for use on the mandible and maxilla

Image: [4]

YOMI Dental Robot – Summary

- Plan is created by the surgeon
- Splint and fiducials are used for registration
- Split and secondary robot arm are used for tracking
- Primary arm cooperatively controls tool movement



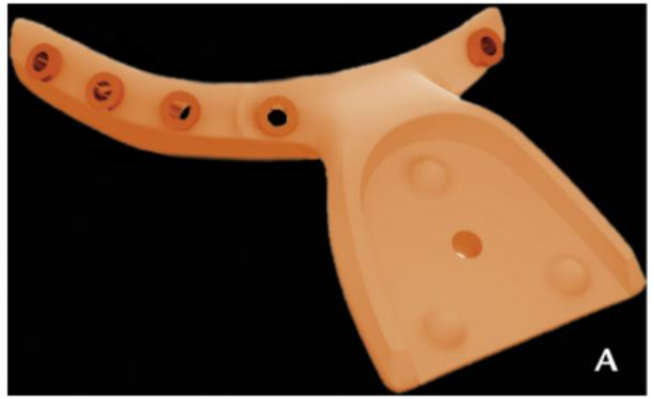


Image: [4]

YOMI Dental Robot – Summary

- Currently, acrylic guides are used to control drilling locations
- Study to show viability with respect to other methods
- 5 patients with 38 dental implants
- Post-op CT to measure deviation from plan

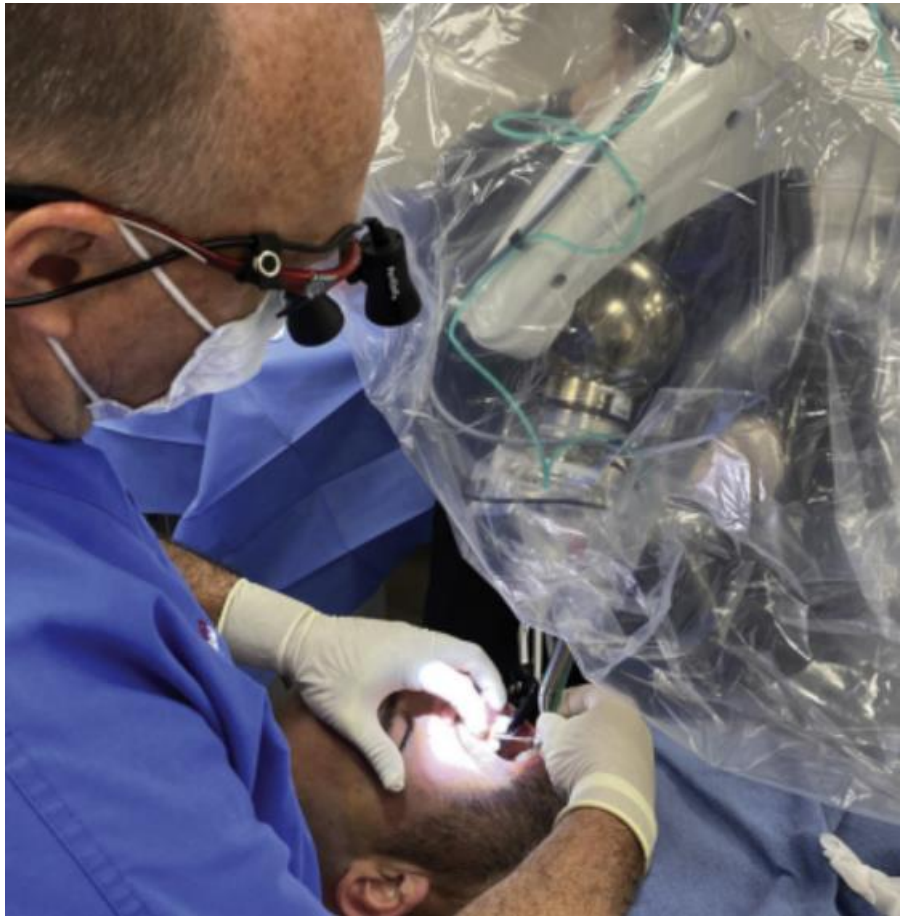


Image: [4]

YOMI Dental Robot – Results

- Angular deviation:
  2.56 ± 1.48 degrees
- Crown placement deviation:
  1.04 ± 0.70 mm
- Apex placement deviation:
  0.95 ± 0.73 mm
- Average depth deviation:
  0.42 ± 0.46 mm
- Similar to non-robotic methods

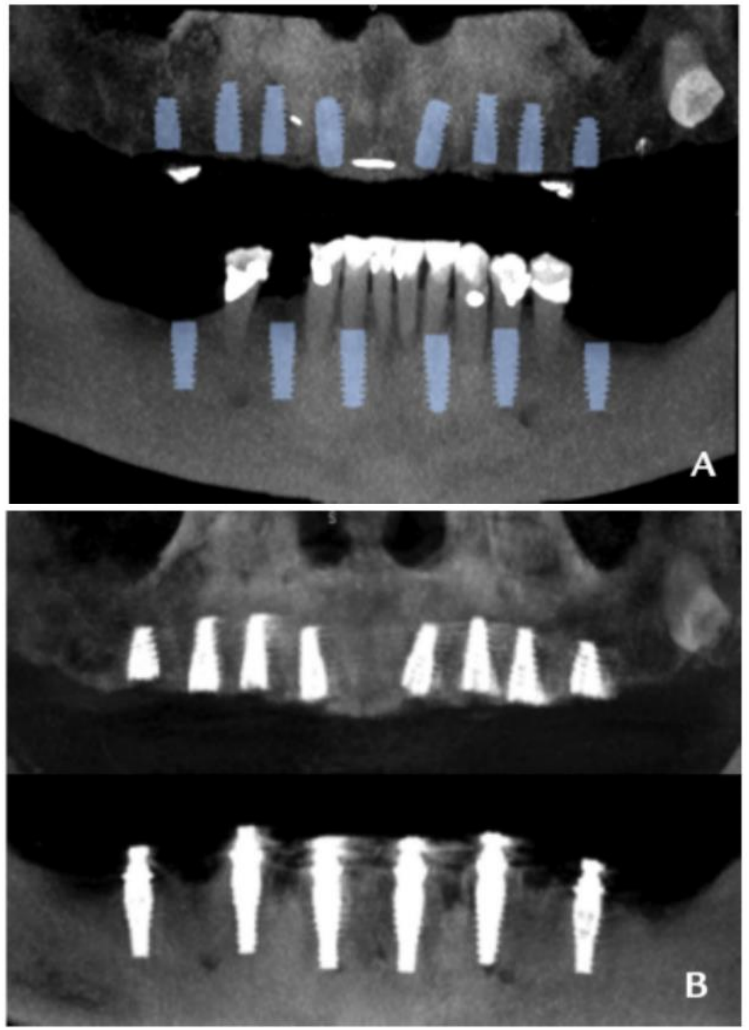


Image: [4]

YOMI Dental Robot – Assessment

Weaknesses:

- No control was used
- Small patient sample size
- Very limited technical description

Image: [4]

YOMI Dental Robot – Assessment

Take Away:

- Feasibility of cooperative robotics on the mandible
- Robot arm tracking method
- Mandible more difficult than maxilla

Image: [4]

Galen Mastoidectomy – Paper Selection

- Feasibility study of Galen robot enforcing virtual barriers for a mastoidectomy [5]
  - Uses the same Galen system
  - Demonstrates enforcing virtual barriers while cutting bone

Image: [5]

Galen Mastoidectomy – Summary

- Mastoidectomy is difficult and time consuming
- Many critical structures to avoid
- 5 DOF robot filters out hand tremors
- Controls tool movement

Image: [4]

Galen Mastoidectomy – Summary

- Pyramid created in 3D Slicer for desired cut area
- Touching 3 points for registration
- Untrained user told to cut without knowledge of planned area
- 5 phantoms cut
- Results confirmed by neurologist

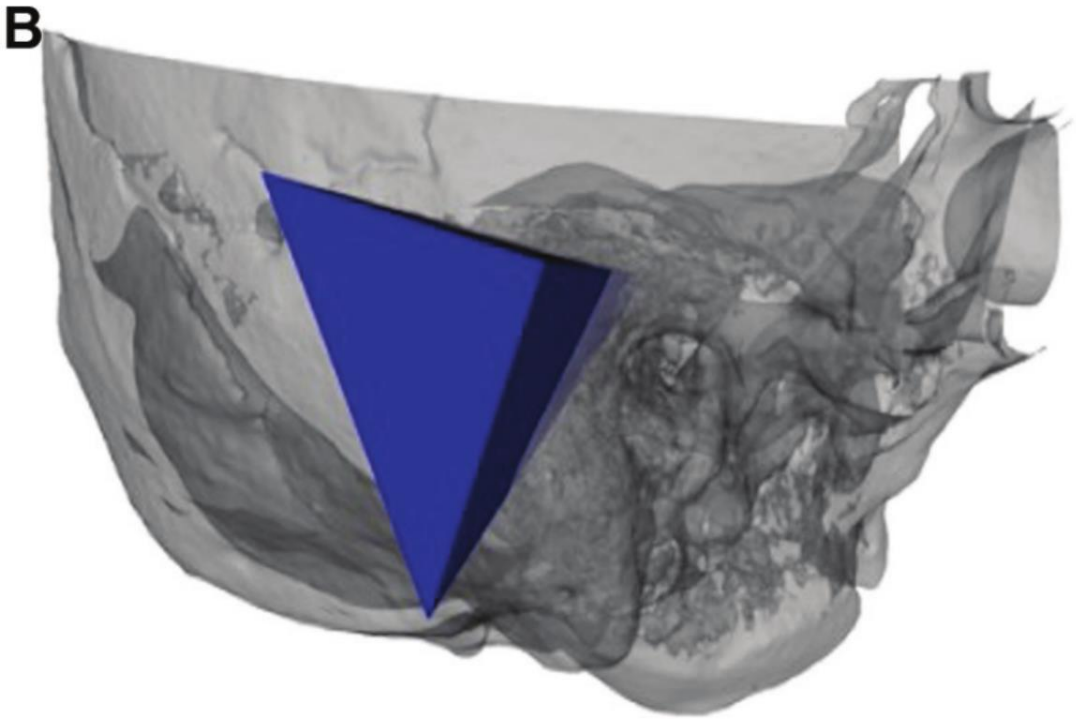


Image: [4]

Galen Mastoidectomy – Results

- Successfully drilled 5 phantoms within target area
- Average completion time of 221 seconds
- Drastically faster than autonomous robot for similar procedure

Image: [4]

Galen Mastoidectomy – Assessment

Weaknesses:

- No direct control for comparison
- Pass-Fail matric
- Small sample of users and phantoms
- 3-point registration
- Limited technical description

Image: [4]

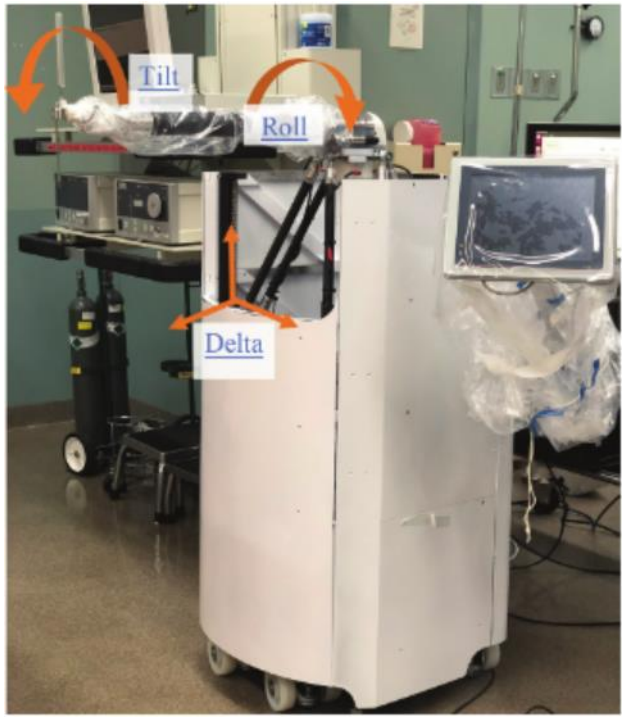
Galen Mastoidectomy – Assessment

Take Away:

- Demonstrates Galen's use on bone
- Feasibility of virtual fixtures
- Removes technical difficulty from the procedure

Image: [4]

Conclusions



- Cooperative robotic workflow on the mandible is feasible
- Registration and tracking strategies
- Different planning and guidance approaches
- Resulting measurement approaches

Image: [4]

Thank You!

References

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5392880/
2. https://www.researchgate.net/figure/A-modified-Obwegeser-Dal-Pont-bilateral-sagittal-split-osteotomy-BSSO-technique-was_fig3_335848383
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3094736/
4. https://doi.org/10.1016/j.prosdent.2020.12.048
5. https://doi.org/10.1177%2F0194599819861526