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A novel drill-milling technology for robot-assisted implant osteotomy preparation: simulation and an ex vivo validation study

Key words: Drill-milling technology; Robot-assisted drilling; Implant osteotomy preparation; Finite-element analysis; Temperature control

Research Summary

Excessive frictional heat generated at the drill–bone interface during implant osteotomy can compromise osseointegration and lead to implant failure. This study introduces a novel helical milling technique designed to minimize thermal damage to bone during dental implant osteotomy preparations.

- **Finite element simulations**

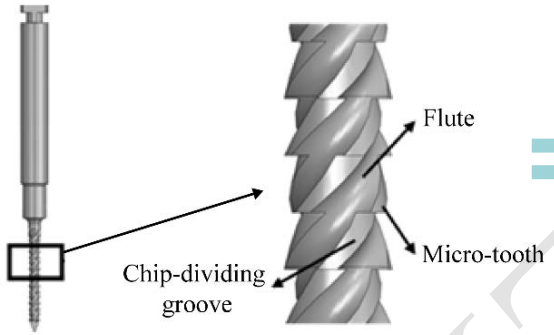
  Helical milling produce a maximum cutting stress higher than drilling with the twist drill, indicating improved cutting efficiency. Furthermore, the helical milling process facilitated efficient bone chip removal, reducing thermal buildup.

- **Ex vitro experimental verification**

  Helical milling technique maintained the drilling site temperature below 38.7℃, which was significantly lower than the clinically critical threshold of 47 ℃.

Innovation points

● The helical milling technology is applied to implant site preparation, replacing the traditional twist drill, and reducing friction heat generation by optimizing the tool geometry.



The micro tooth is designed with 1.778 mm in length, 2.732 mm in width, 1.442 mm of flute width, and with a 45° helix angle.

The helical milling for implant osteotomy was integrated into a robot-controlled moving arm in a helical trajectory to complete the drilling process.

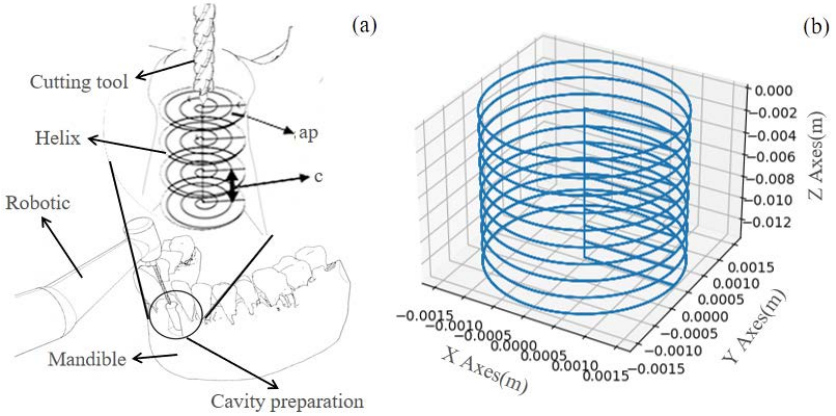
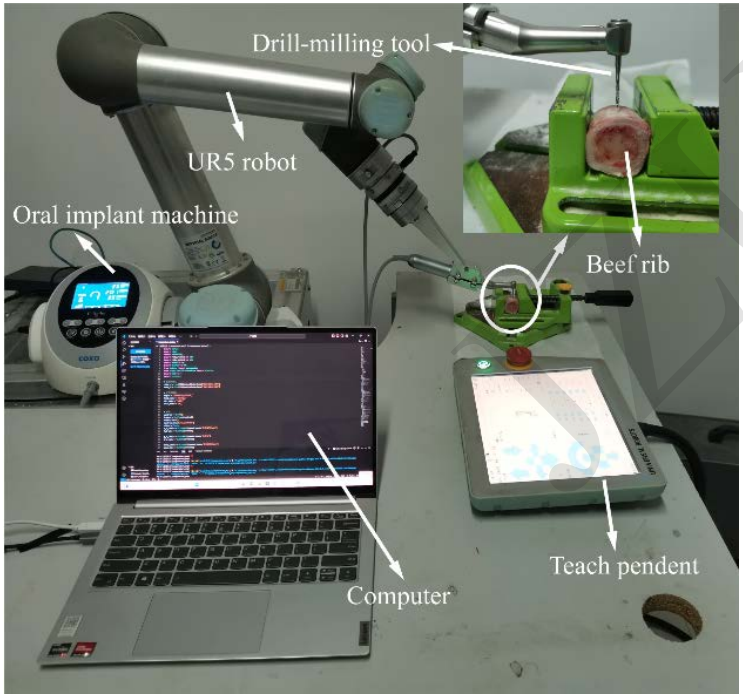


Figure 1

Innovation points

- Propose a robot assisted precise temperature control scheme, combined with finite element simulation and ex vivo experimental verification, to reduce the drilling temperature to 38.7 ℃.



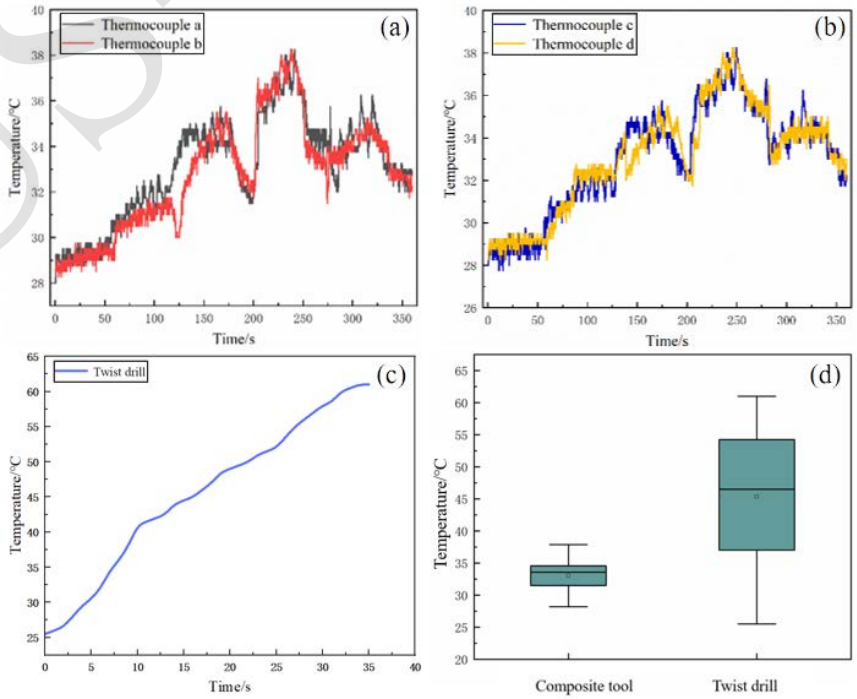


Figure 2