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Hear Restore RTD 2013

FNSNF

Measurement of Temperature Distribution during Drilling in Bone

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Introduction:
In the HearRestore project, we aim to develop a surgical robot system dedicated for image-guided microsurgery, enabling minimally invasive and atraumatic cochlear implantation.

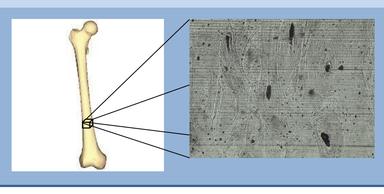
Minimally invasive cochlear implantation involves the drilling of a tunnel from the surface of the mastoid bone, behind the ear, to the cochlea. The accurate placement of this tunnel is of vital importance as it must pass through a region densely populated with vital anatomy, including the facial nerve, which the trajectory generally passes within 0.5 mm. In such close vicinity, heat and vibrations generated by drilling are of potential danger to this and other critical structures. To ensure safe and atraumatic drilling of the trajectory, the process of bone removal should be fully understood.

Therefore, a new test stand was designed to evaluate all necessary parameters and to improve the drilling process. The goal is to minimize the drilling temperatures, forces and torques. The experimental results will be compared with the computational model.

modify input parameters

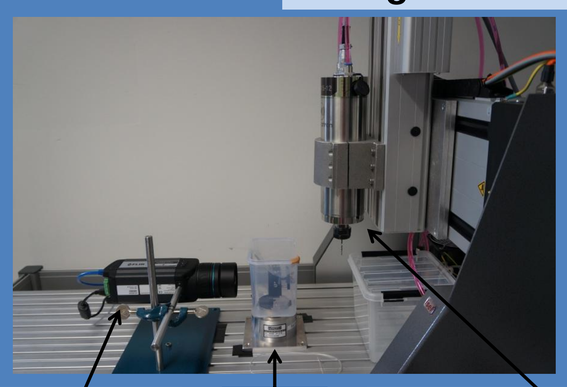
Input Parameters:
- Rotational speed
- Feed rate
- Irrigation (amount; internal or external)
- Drill bit design

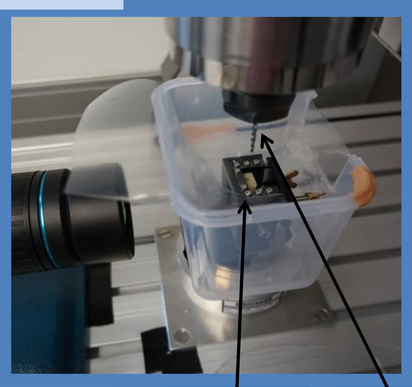
Bone Samples
- Bovine milk cow
- Femur or tibia



Experimental Definition of the Emissivity of Bone:
- ε=0.95 (for fine surfaces)
- ε=0.96 (for rough surfaces)

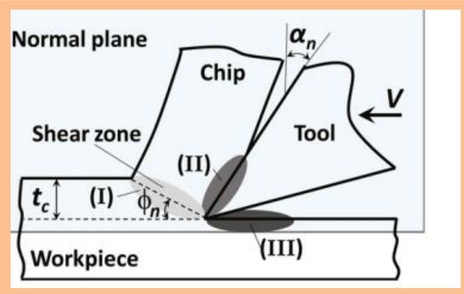
Design of Test Stand:





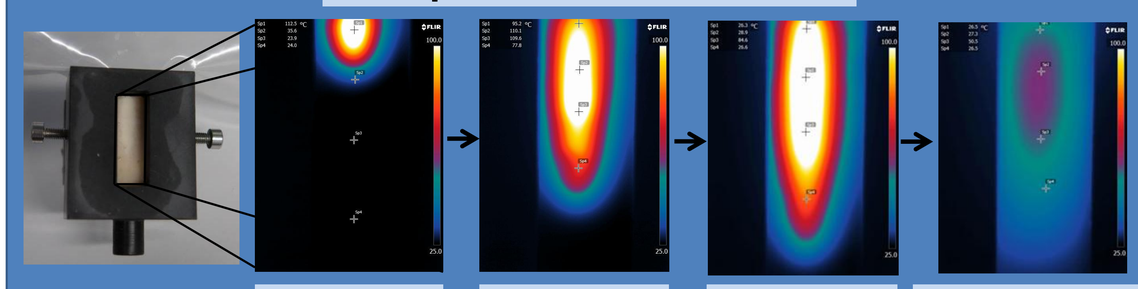
Infrared-camera | Load cell | Motor Spindle and CNC-machine | Bone Sample | Drill Bit

Computational Model:
- Computational model for prediction of drilling forces and temperature
- Model based on the unified cutting theory that uses orthogonal cutting data [Armarego, 2000]
- Thermal conductivity of bone as input parameter



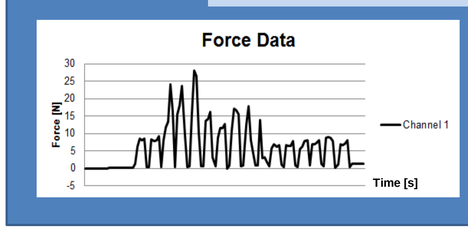
[Lee *et al.*, 2011]

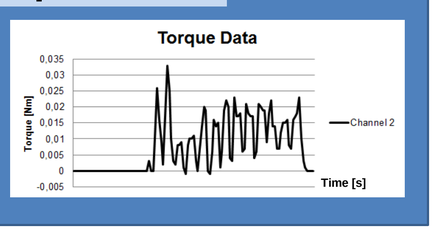
Temperature Distribution:



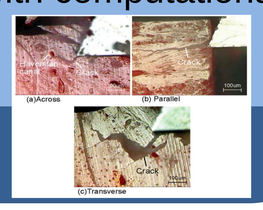
ca. 10 mm drilling depth | ca. 20 mm drilling depth | ca. 30 mm drilling depth | decrease after subtraction of drill bit

Force and Torque Data:





Results and Discussions:
- Evaluation of drilling temperature and force/ torque data
- Finding optimal input parameters and explaining micro cutting effects
- Comparison of forces, torque and temperature with computational model
- Recursive improvement of model



[Sugita *et al.*, 2009]

compare

References:
Armarego,2000,Machining Science and Technology
Lee, Rabin, Ozdoganlar,2011,Medical Engineering & Physics
Sugita et al.,2009,CIRP Annals - Manufacturing Technology