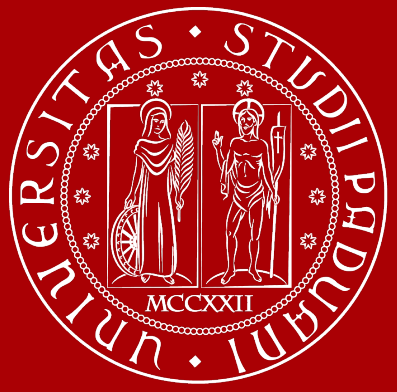

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Development and performance analysis of techniques for mandibular movement measurement.

Chiara Valenti 39th Cycle

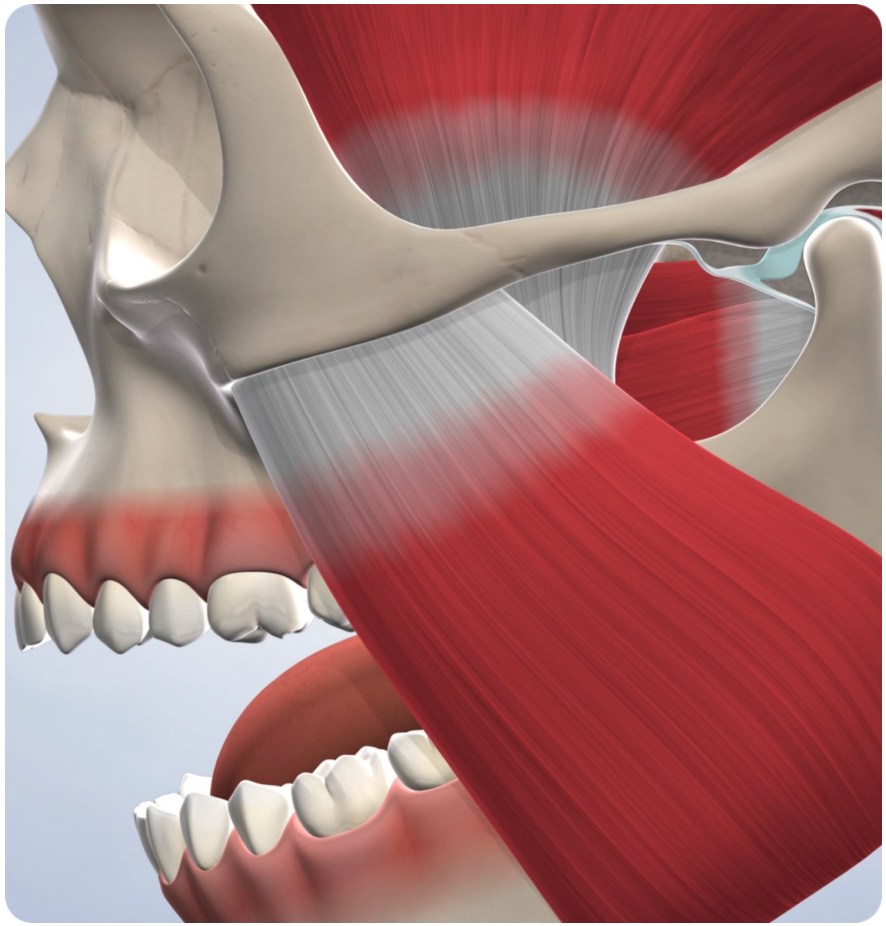
Supervisor: Prof. Gianluca Rossi

19 / 10 / 2023

Clinical significance

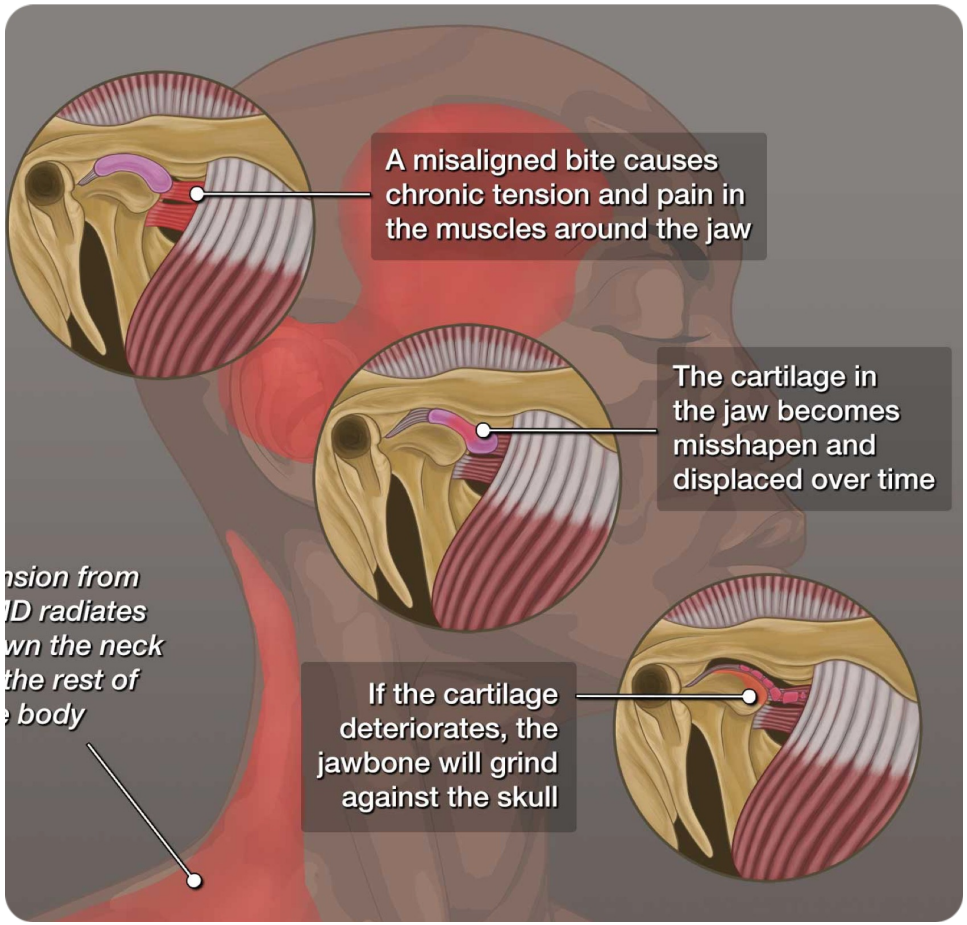
The temporo-mandibular joint (TMJ) is one of the most complex joints in the human body, with many associated pathologies, referred to as temporo-mandibular disorders (TMDs), with a variety of symptoms: loco-regional facial and/or pre-auricular pain, limitation of jaw movements and excursions, clicking or locking of the joint.

> TMDs are common to a large part of the population.



Li DTS et al.Temporomandibular Disorders: Current Concepts and Controversies in Diagnosis and Management. Diagnostics (Basel). 2021

Clinical significance



TMDs include many different conditions with difficult dental treatments.

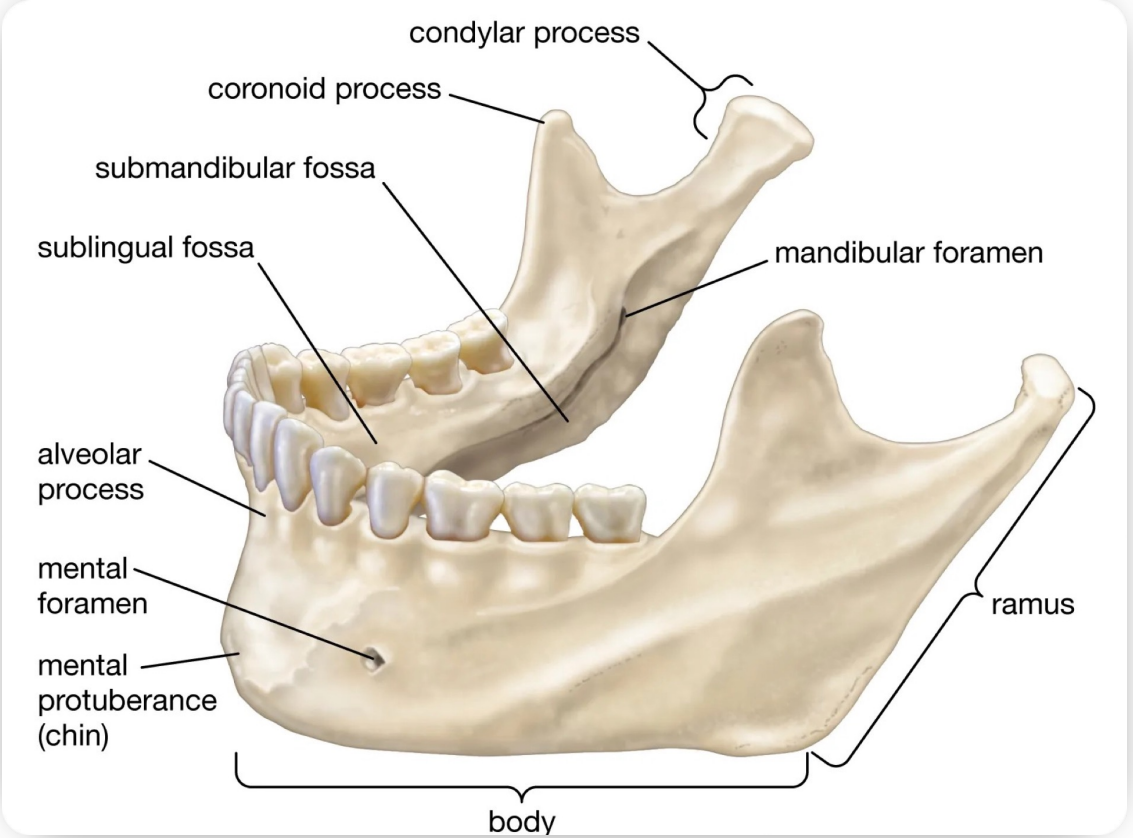
It is essential to assess the movements of the stomatognathic apparatus and masticatory traces for an accurate diagnosis and therapeutic approach.

Schiffman E et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group†. J Oral Facial Pain Headache. 2014.

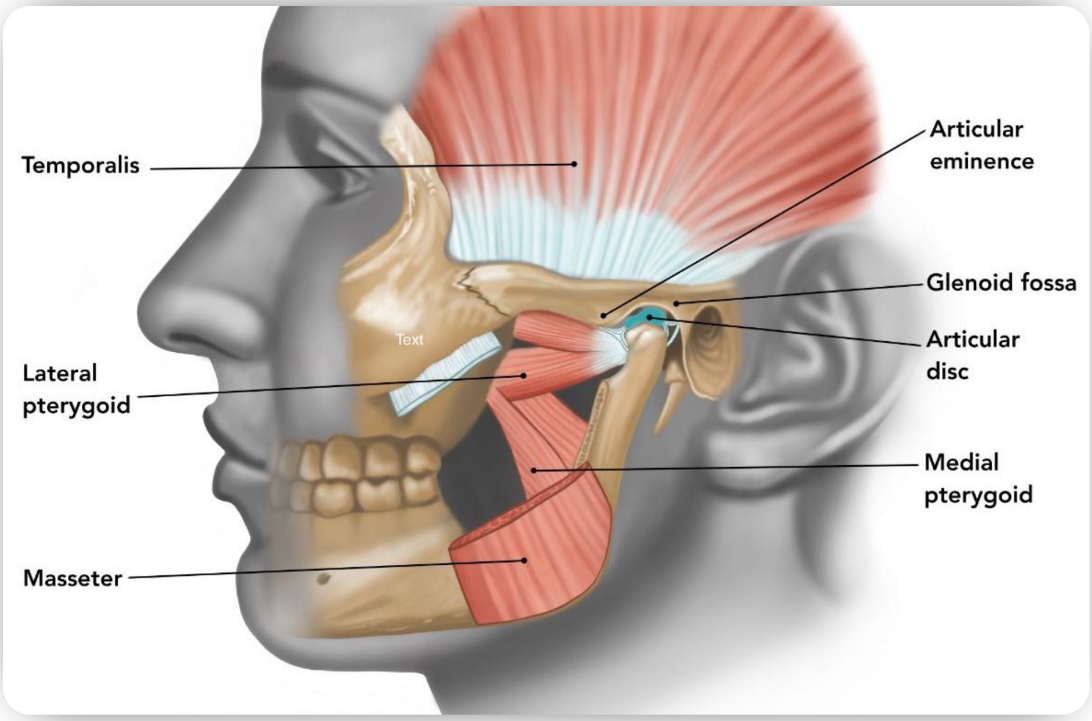
Anatomy and biomechanics

The bilateral condylar heads of the mandible are located in the glenoid cavities, with an articular disk in between, held in place and moved by a ligament connected to the lateral pterygoid muscle.

The articular eminence defines the condylar path: the shape and curvature of the eminence vary between different individuals > characteristic movement of the mandible.



Anatomy and biomechanics



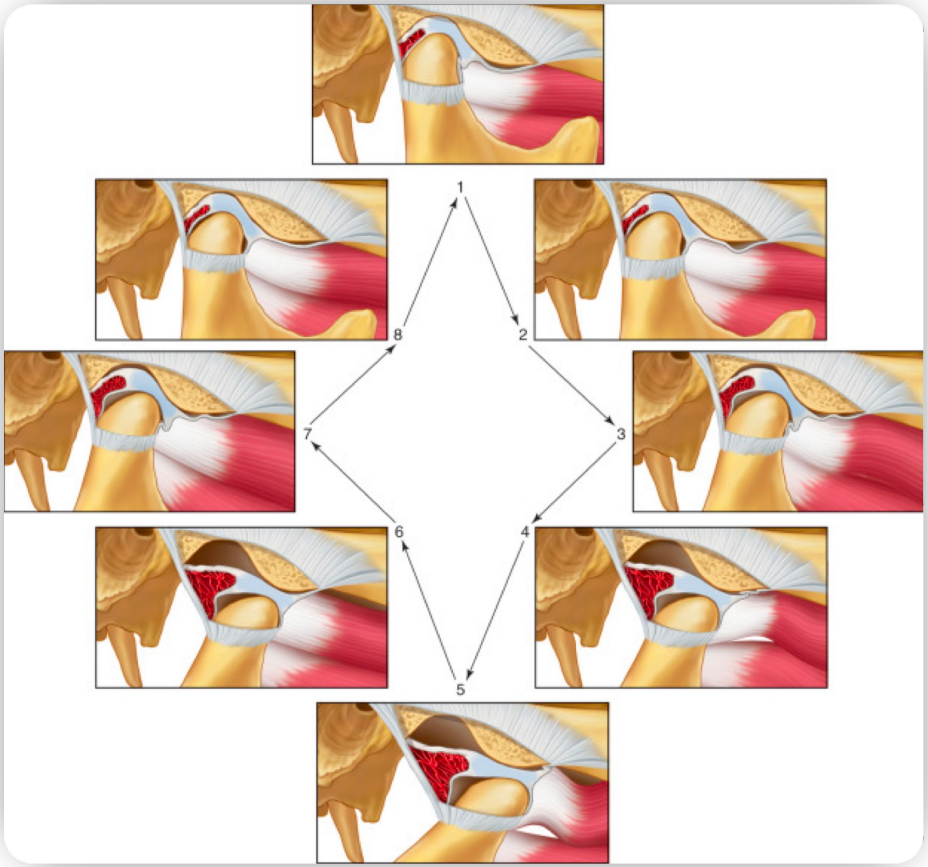
Opening / jaw depression: Lateral pterygoids and digastric.

Closing / jaw elevation: Temporalis, masseter, and medial pterygoid.

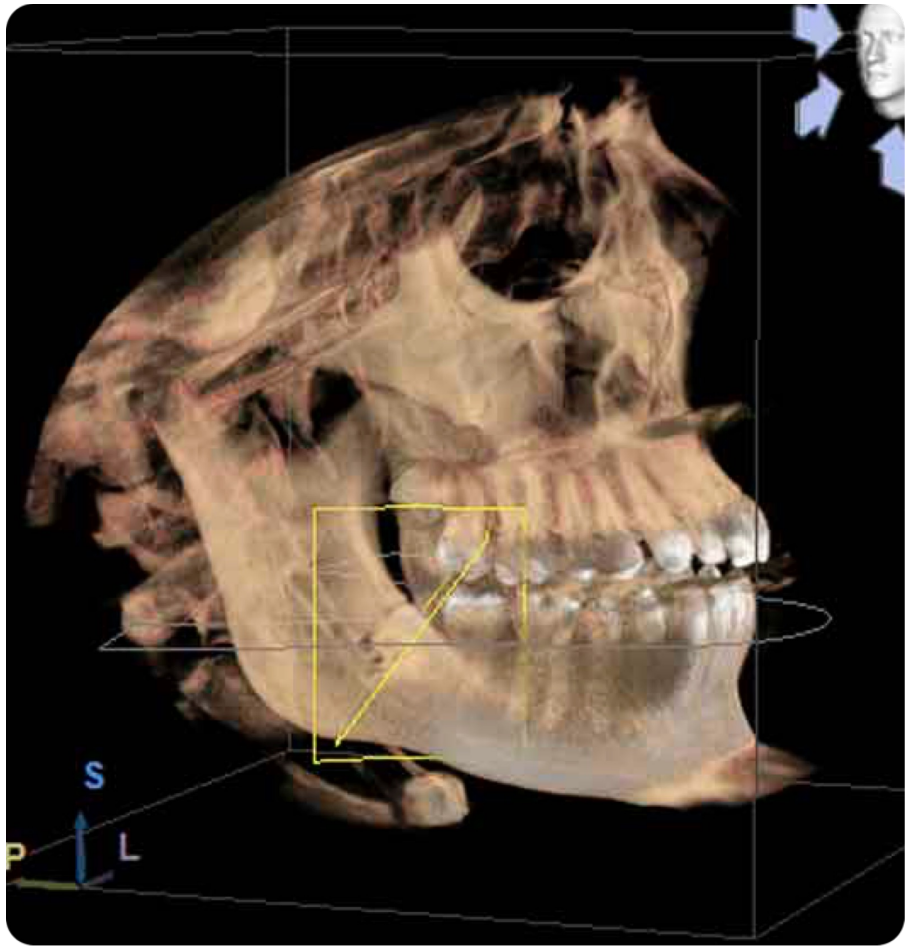
Anatomy and biomechanics

The sides of TMJ cannot work completely independently of each other, but rarely perform the same movements simultaneously.

Mandibular kinematics is characterized by six degrees of freedom (6DOF) and consist of a combination of 3 translational and 3 rotational movements.



Motion tracking devices



Bartlett MS, et al. Measuring facial expressions by computer image analysis. Psychophysiology. 1999

New digital measurement method and related instrument to record jaw motion applied to the dental field characteristics:

- accurate and reliable measurements.
- more comfortable for patients.
- without occlusal interference.
- production of efficient prosthetic devices in less time and with fewer post-production corrections.
- replacement of traditionally used analog systems and complete digitalisation of protocols.

Motion tracking devices

The objective clinical examination is the gold standard in the diagnosis of tmds. Various supporting devices have been proposed to avoid operator-dependent errors and to overcome the non-univocal technique of traditional gnathological examination.

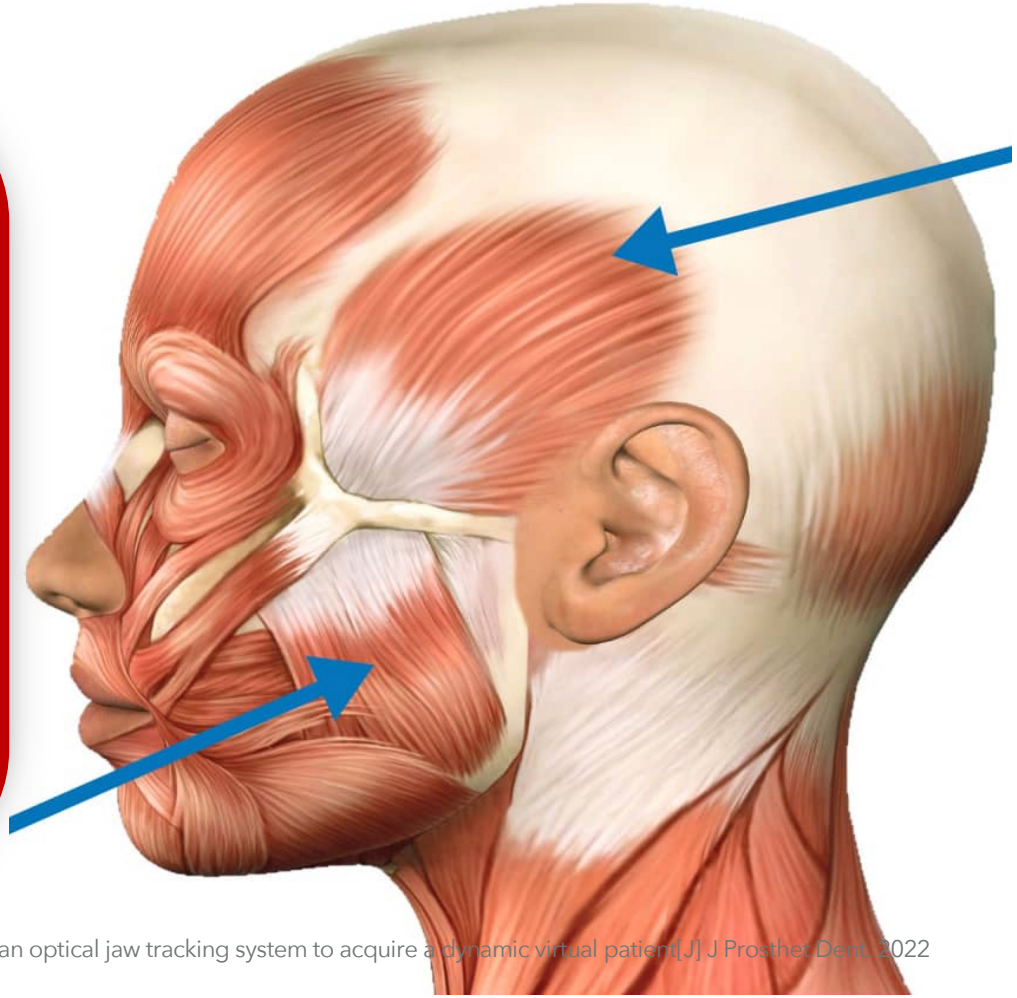
Revilla-León M et al. Digital maxillomandibular relationship and mandibular motion recording by using an optical jaw tracking system to acquire a dynamic virtual patient[J] J Prosthet Dent. 2022

Motion tracking devices

In-depth study of different clinical techniques:

> Analysis of pros and cons.

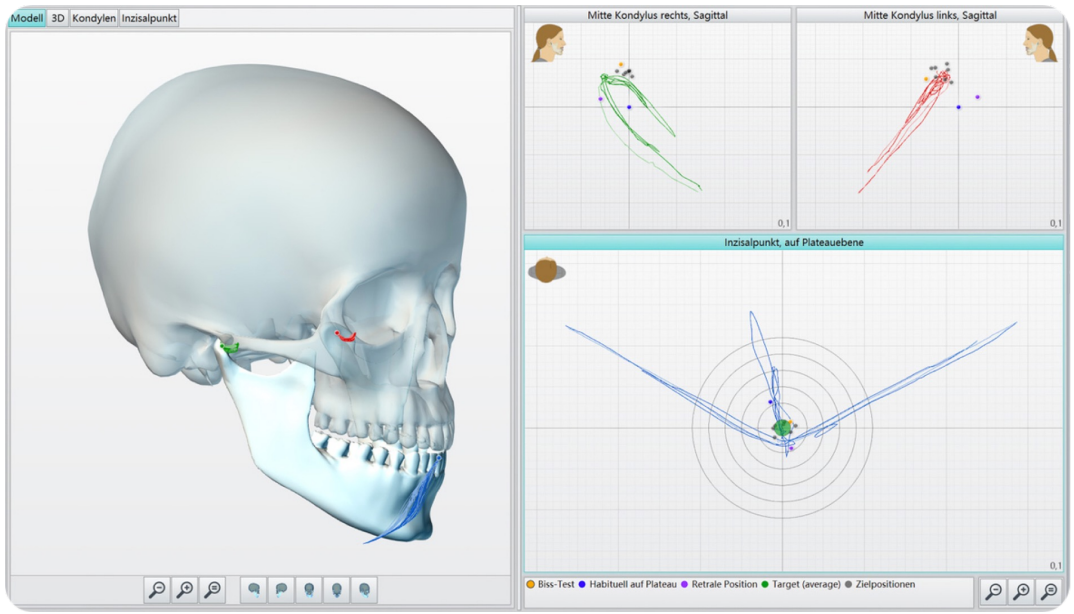
> Evaluation of the repeatability and reproducibility of the measurements.



Revilla-León M et al. Digital maxillomandibular relationship and mandibular motion recording by using an optical jaw tracking system to acquire a dynamic virtual patient[J] J Prosthet Dent, 2022

Motion tracking devices

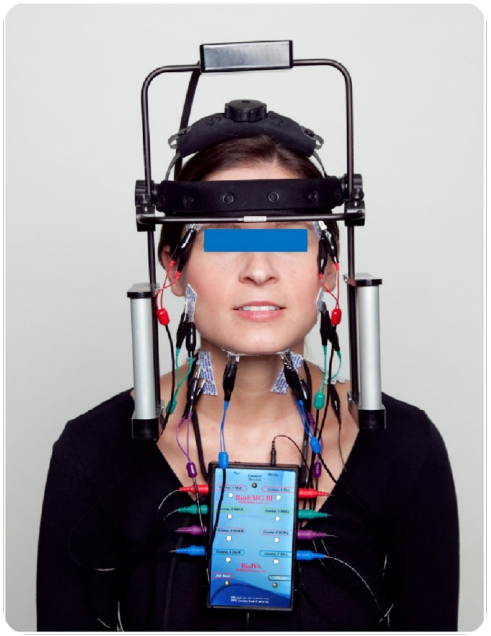
ultrasonographic: emit ultrasonic pulses from the lower mandibular facial arch to sensors located on the upper facial arch. Mandibular movement is measured by computerised calculation of the pulse-travel-time between emitters and sensors.

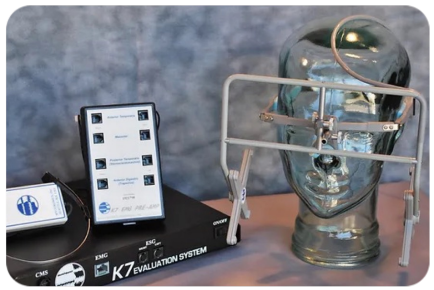


Jakubowska S. Et al., Jaw motion tracking systems – literature review. Prosthodontics, 2023.

Motion tracking devices

electromagnetic sensors: calculate the spatial position of the target by detecting changes in the surrounding magnetic field. > not accurate in determining intercondylar axis, possible occlusal interference, heavy instrumentation.





Jakubowska S. Et al., Jaw motion tracking systems – literature review. Prosthodontics, 2023.

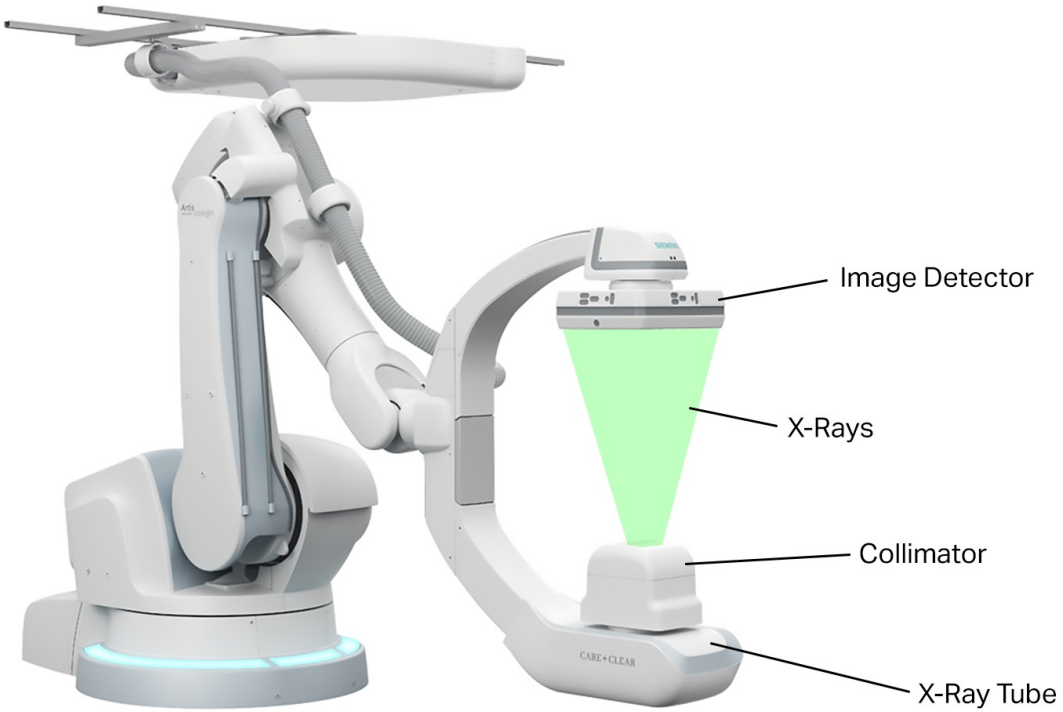
Motion tracking devices

optoelectronic imaging: based on the emission of infrared light by markers located on the face. > possible risk of skin artefacts due to instability of extra-oral markers.



Jakubowska S. Et al., Jaw motion tracking systems – literature review. Prosthodontics, 2023.

Motion tracking devices



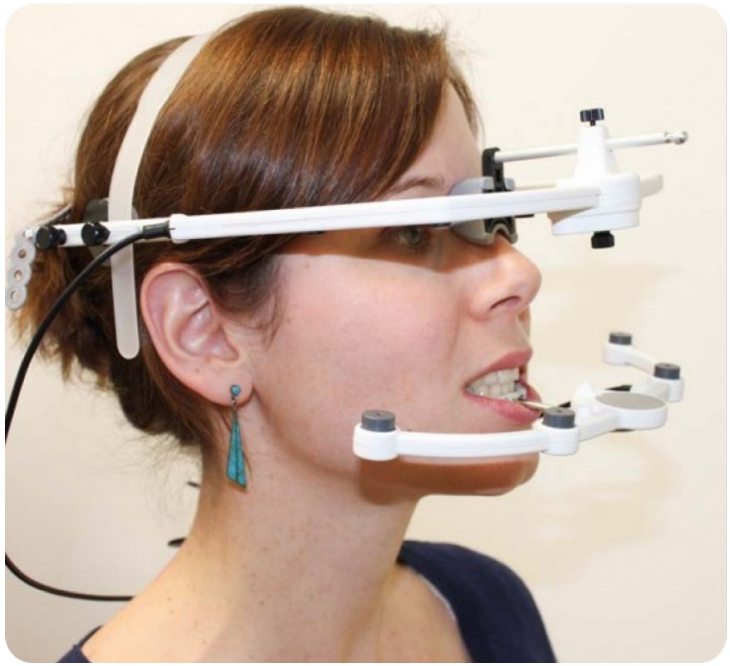
radiographic video x-ray fluoroscopy: projection obtained combining CT image with dynamic 2D fluoroscopic registration, creating a 3D jaw movement.

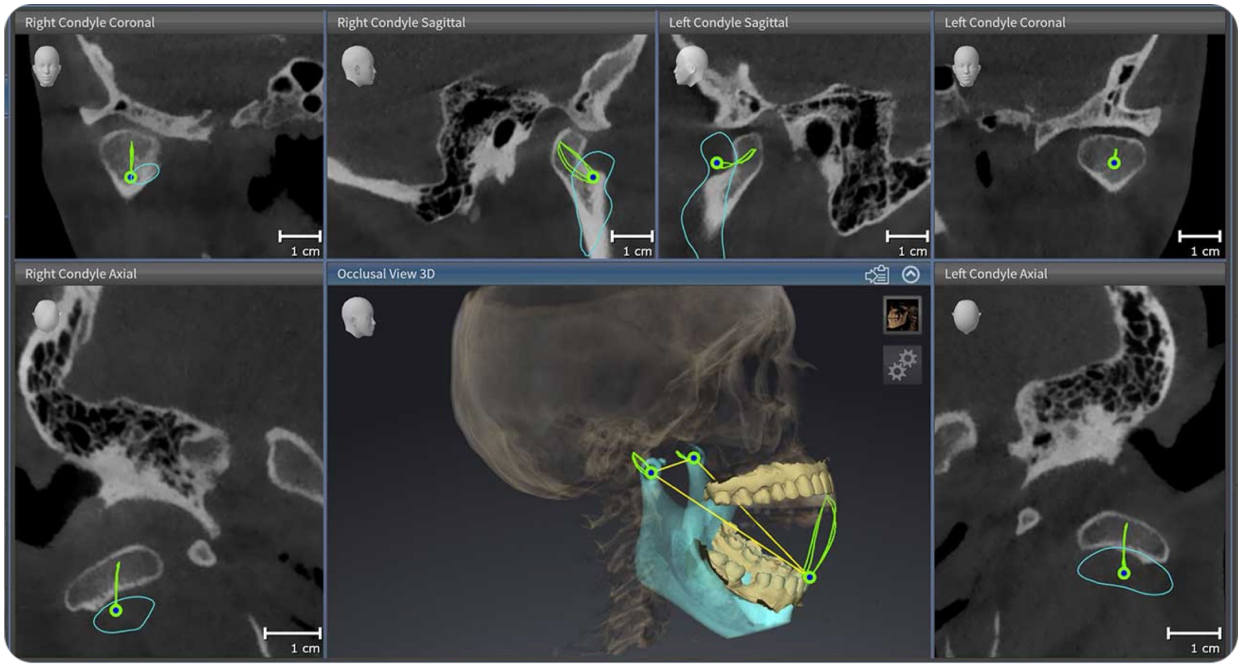
> radiation dose for 10s examination (without CT) reaches approx. 135 microSv. Another concern is the reliability of the measurements, especially during dynamic movements (registration speed of about 7.5 frames/s).

Jakubowska S. Et al., Jaw motion tracking systems – literature review. Prosthodontics, 2023.

Motion tracking devices

4D computed tomography: directly measure and reconstruct mandibular kinematics in a virtual environment, merging the recording with CBCT image.

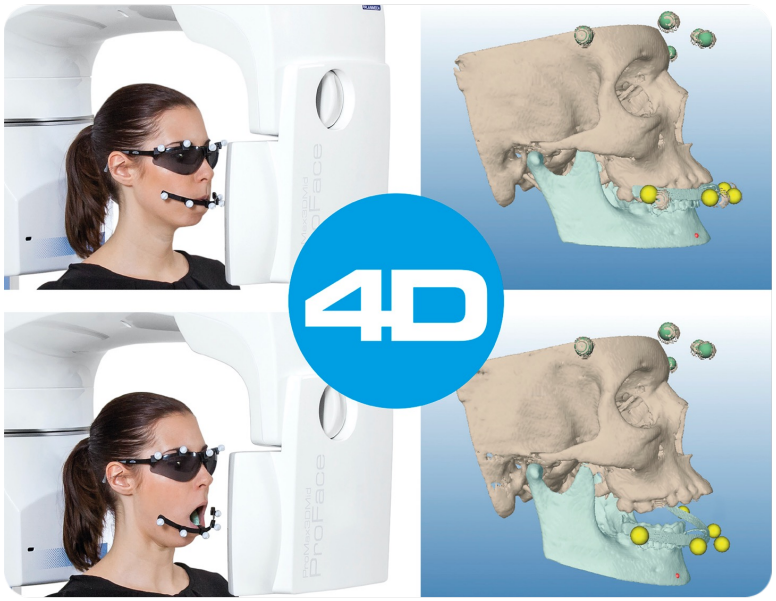


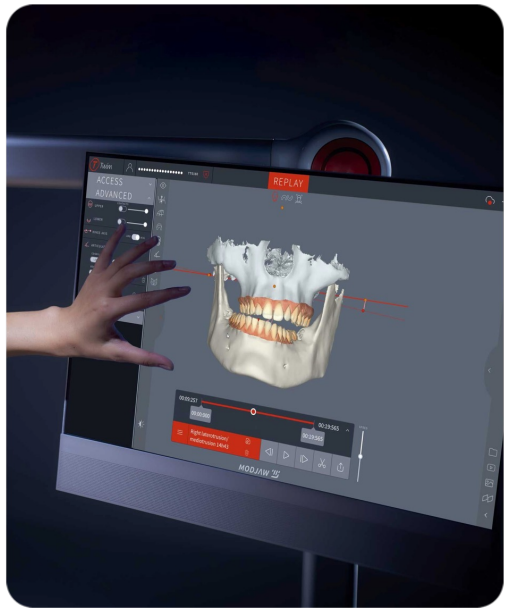


Jakubowska S. Et al., Jaw motion tracking systems – literature review. Prosthodontics, 2023.

Motion tracking devices

4D computed tomography: This method has proven useful in post-operative surgical and orthognathic evaluation > there remains the ethical problem of radiation exposure affecting both joints and the upper and lower jaw.





Jakubowska S. Et al., Jaw motion tracking systems – literature review. Prosthodontics, 2023.

Motion tracking

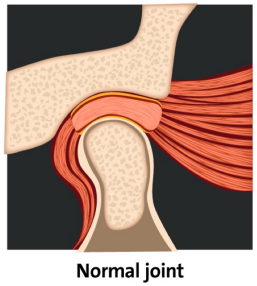
Digital dentistry has developed rapidly in recent years, but a complete digital workflow requires the use of virtual instruments for the analysis of occlusion and jaw movement.

Innovative digital measurement techniques have been proposed in the dental field that can more closely replicate articular paths.

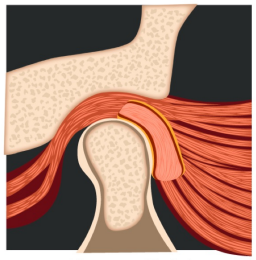
To date, it is still not possible to reliably represent the complex organisation of masticatory acts and excursions, making therapeutic solutions approximate.

Li Q, et al. The creation of a virtual dental patient with dynamic occlusion and its application in esthetic dentistry[J] J Prosthet Dent. 2021

AIM



Normal joint



Abnormal joint
(dislocated disk)

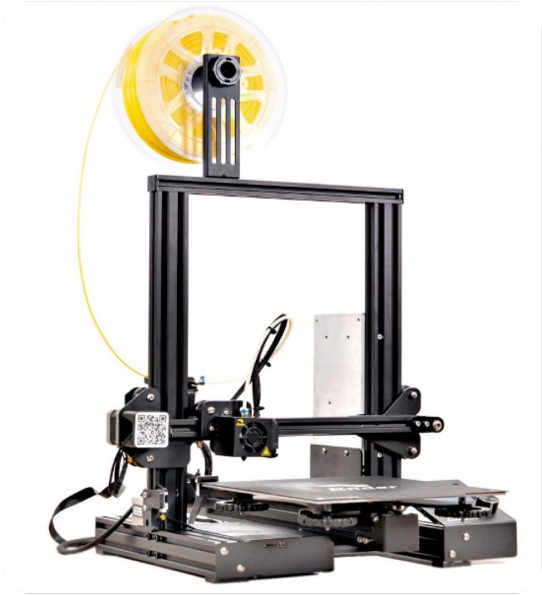
Abnormal joint
(arthritic)

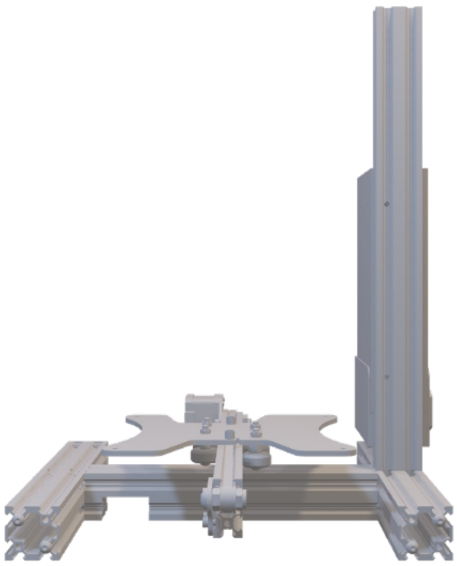
ANALYZING THE METROLOGICAL CHARACTERISTICS OF DEVICES AND CONDUCTING AN UNCERTAINTY ANALYSIS TO DEFINE ACCURACY AND RELIABILITY.

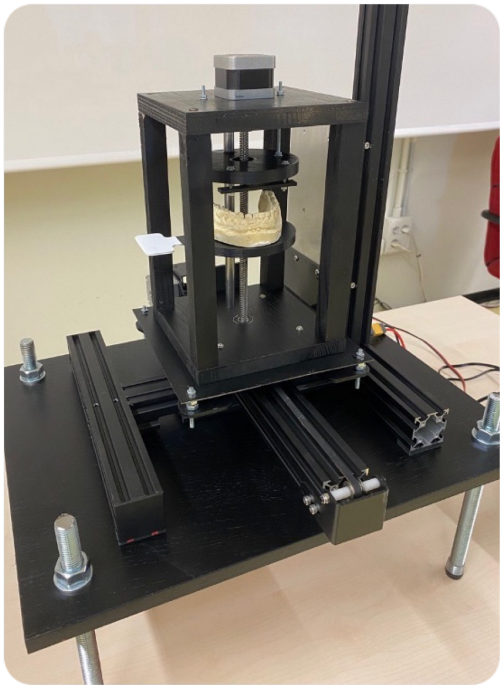
STUDY OF A METHOD FOR RECORDING MANDIBULAR MOVEMENT AND DEVELOPMENT OF A NEW EXPERIMENTAL DEVICE.

Preliminary study

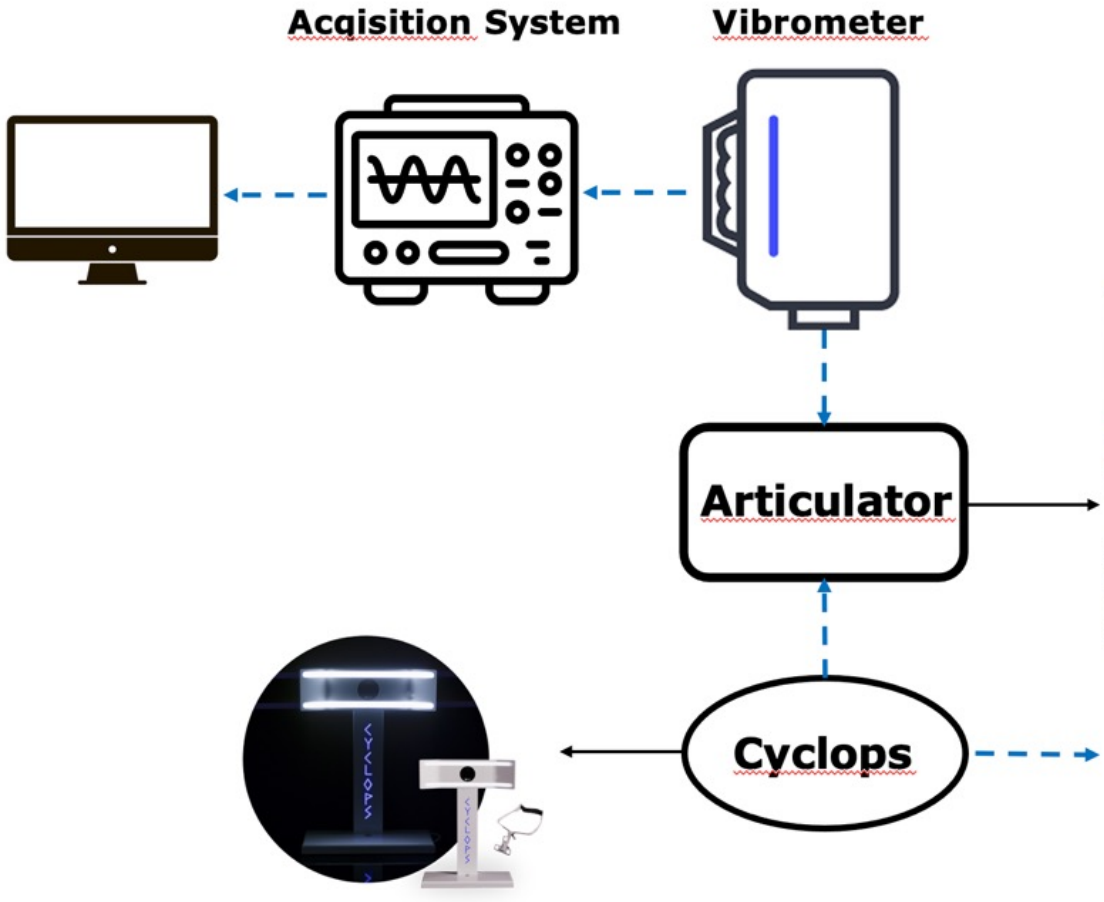
Realisation of a simulation machine capable of replicating a simple, standardised and regular movement (opening/closing) using: part of the structure and electronic components of a Creality Ender 3 Pro 3D printer, 3D printed PLA parts and a plaster cast of a mouth to emulate the lower dental arch.

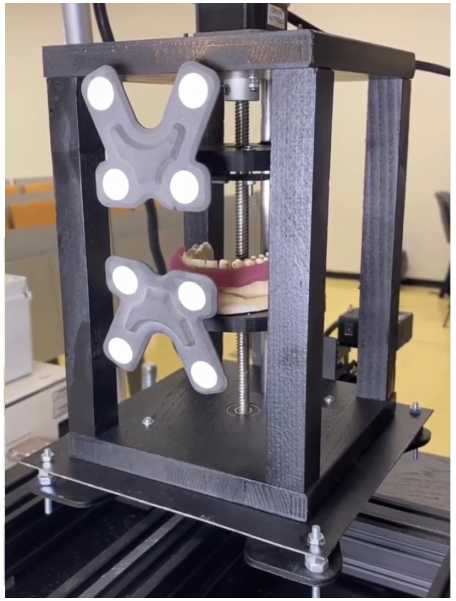


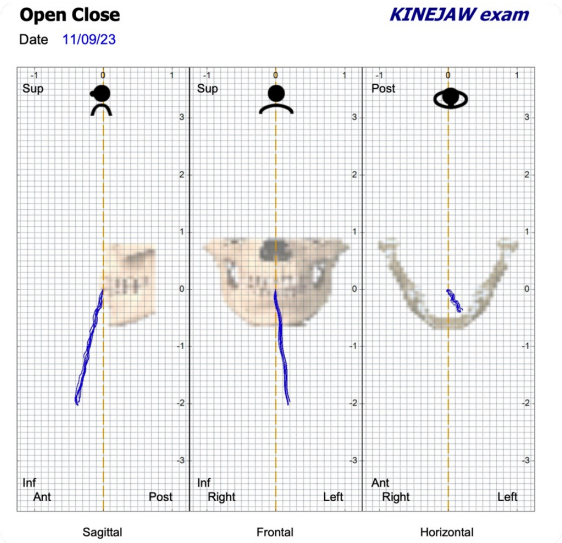




Preliminary study: test bench



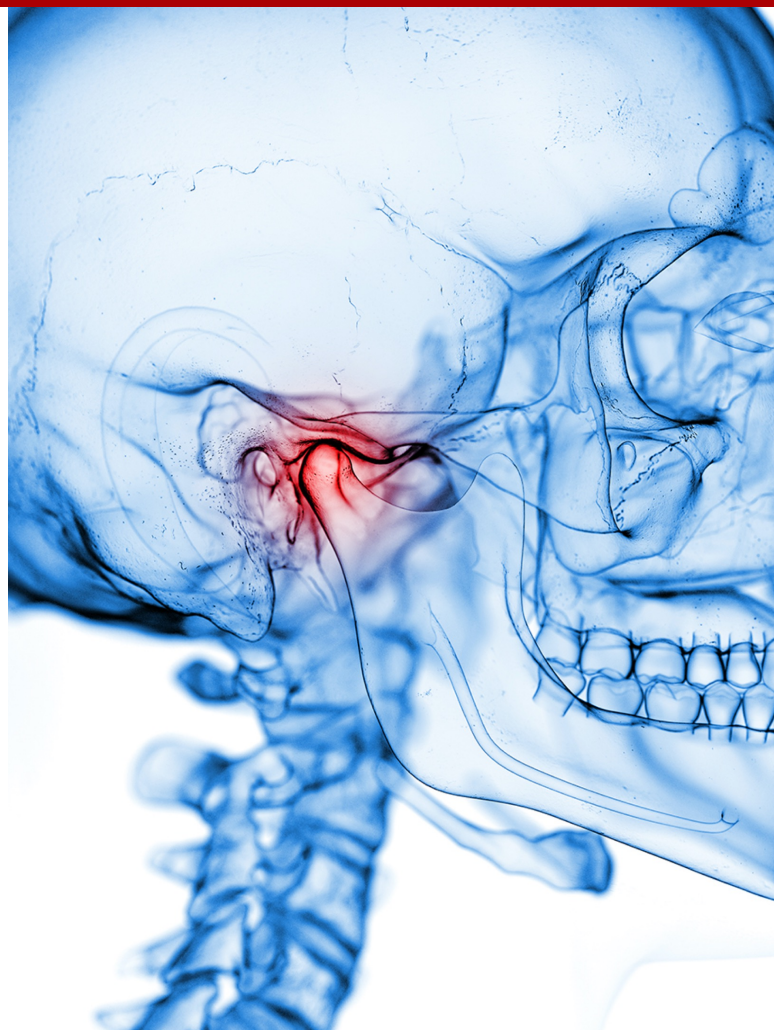




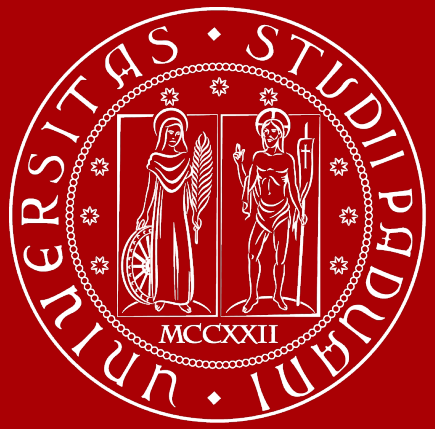
Perspectives

Analysis of the uncertainty of current measurement instruments and development of new measurement systems and techniques:

- SELECT EFFECTIVE GNATHOLOGICAL AND PROSTHETIC TREATMENTS.
- CHOOSE APPROPRIATE MATERIALS AND MANUFACTURING TECHNIQUES.
- FULLY DIGITAL WORKFLOW WITH REDUCED COSTS.
- DIAGNOSTIC TOOL TO RECOGNISE PATHOLOGIES AND PARAFUNCTIONS.



Thanks for the attention



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