Craniofacial research

Programme Leader: Professor Mauro Farella

Deputy Programme Leader: Associate Professor Peter Li Mei

The Craniofacial Research programme encompasses a diverse range of exciting fields, including the basic and molecular sciences relevant to craniofacial growth, the impact of malocclusions on oral health, jaw function, self-esteem, psychological wellbeing, and the understanding of the peripheral and central mechanisms of orofacial pain and jaw dysfunction with their clinical correlates.

Several research approaches are used to study topics relevant to craniofacial research, including cell response to mechanical loading, animal models, and clinical genetics. The latter focuses on identifying genetic markers for some dentofacial anomalies which could potentially provide us with a clinically important window of opportunity to predict abnormal growth patterns at an early age and, possibly, to provide personalized orthodontic treatments.

An additional area of active research is focusing on the development of novel treatment strategies for clinical problems such as craniofacial syndromes, jaw discrepancies and misaligned teeth. Furthermore, the impacts of craniofacial anomalies and smile problems are quantitatively and qualitatively assessed at population and individual level using survey methods including social media. Social media enables us to gather opinions from the public about the importance of smiles for individuals themselves and also the perspective of their peers.

Craniofacial research examines mastication and jaw kinematics, bruxism and non-functional oral behaviours, sleep disordered breathing including snoring and sleep apnea, intra-oral tongue pressure, dysphagia, tooth wear, eating behaviour, and novel food products. We are currently using wired and wireless sensors to monitor intraoral pH, temperature, and jaw activity for the purpose of identifying and evaluating ways of overcoming orofacial pain, dental wear, jaw dysfunction, jaw clicking sounds, snoring, and obstructive sleep apnea. We also use monitoring equipment to improve the quality of sleep in New Zealand children and adults.

Key personnel

Staff

Professor Mauro Farella
A/Prof Li Mei
Dr Joseph Antoun
Florence Bennani
Prof Richard Cannon
A/Prof Rohana De Silva
Professor Mauro Farella
Dr Fiona Firth
Dr Winifred Harding
Dr Hannah Jack
Dr Austin Kang
Dr Carolina Loch
Dr Trudy Milne
Dr Christopher Robertson
Dr Suzan Stacknik
Prof Murray Thomson
A/Prof Geoffrey Tompkins
A/Prof Jonathan Broadbent
A/Prof Nick Chandler
Prof Warwick Duncan
A/Prof Mani Ekambaram
A/Prof Lyndie Foster Page
A/Prof Nick Heng
Dr Benedict Seo
Dr Ajith Polonowita
Dr Simon Guan

Postgraduate students

PhD
Hisham Yasser
Sabarinath Prasad
Joseph Antoun

DClinDent
Nick Pittar
Sherry Lee
Teddy Nguyen
Julia Smith
Reginald Kumar
Michael Skilbeck
Margie Paterson
Gracie Nichols
Rachel Farrar
James Millar
Danielle Hodgkinson
Ghassan Idris
Simon Olliver
Wei Lin
Ana Low
Caleb Lawrence
Divya Ramanan

A/Prof Li Mei, Prof Mauro Farella, Danielle Hodgkinson and Dr Austin Kang.

Current research projects

Relationship between chewing features and body mass index in young adolescents

Ghassan Idris, Claire Smith, Barbara Galland, Rachel Taylor, Chris Robertson, Hamza Bennani, Mauro Farella

Behavioural aspects of chewing may influence food intake, nutritional status and in turn body weight. This study aimed to study chewing features in adolescents as they naturally occur in home-based settings, and to test for a possible association with weight status. Our findings suggested that adolescents who are overweight eat at a slower pace for a shorter period of time than their counterparts who are a healthy weight. This unexpected finding based on objective data appears to conflict with existing questionnaire findings but provides impetus for further work testing the effectiveness of changing eating behaviour as a weight-management intervention in youth.

Ecological momentary assessment of pain in adolescents undergoing orthodontic treatment using a smartphone app

Will Sew Hoy, Joseph Antoun, Wei Lin, Nick Chandler, Tony Merriman, Mauro Farella

The purpose of this study was to determine the feasibility of a smartphone application (app) to assess pain levels in real life, and to test their association with gender, age, time in orthodontic treatment, and type of orthodontic adjustment. Eighty-two participants undergoing orthodontic treatment were recruited. A newly developed app was used to assess pain scores at regular intervals in the three days after adjustment of braces. Resting and chewing pain were assessed using sliding digital visual analogue scales. The mean age of the sample was 15.2 ± 1.6 years, the mean time in treatment was 12 ± 8.4 months, and the majority (56.1%) were females. Resting pain and chewing pain at the teeth rose steadily from baseline, peaked at approximately 20 hours, then decreased gradually over the next two days. Details of the orthodontic adjustments were associated with the total pain experienced at the teeth, with new bond-ups resulting in significantly more pain than routine orthodontic adjustments. Pain levels were not significantly associated with age, gender, or time in treatment. This smartphone app shows promise in measuring orthodontic pain in the real world, and will aid future research projects which investigate various factors that could influence pain severity.

Smart-phone assisted monitoring of jaw muscle activity in freely moving individuals with and without myogenous temporomandibular pain

Sabarinath Prasad, Divya Ramanan, Michael Paulin, Richard Cannon, Mauro Farella

This study aimed to collect objective data on masticatory muscle activity during wake-time in the natural environment using a smart-phone assisted wireless electromyographic (EMG) device; and to compare the features of masticatory muscle activity between females with myogenous temporomandibular disorder (TMD) and age-matched pain-free controls.

A young adolescent wearing our electromyographic device and the wearable camera (indicated by arrows) as used in the study.

Smart-phone assisted EMG device developed at the University of Otago for continuous monitoring of jaw muscle contractions. The device provides a comprehensive analytical tool to estimate when, how often, how long, and how strongly the jaw muscles contract.

EMG activity was detected unilaterally using a minimally invasive wireless EMG device attached to the skin overlying the masseter muscle and connected to a smart-phone serving as data logger (above). Study participants performed a series of standardised tasks in a laboratory setting, wearing both the wireless device and reference standard EMG equipment, and then wore the wireless device for at least eight hours while performing their normal routine activities. For our second aim, EMG activity was collected in females with myogenous TMD and in age-matched pain-free controls while performing

their normal routine activity over two consecutive days. The wireless device reliably detected masseter muscle contraction episodes under both laboratory and natural environment conditions, with most masseter contraction episodes during normal routine being of low amplitude and short duration. A significant difference in total jaw contraction time was found, with longer contractions in the TMD pain group. No significant association was found between self-reported parafunction and masticatory muscle activity. Smart-phone assisted monitoring of the jaw muscles represents a promising tool to investigate oral behaviour patterns in orthodontic patients.

Is posterior crossbite a risk factor for temporomandibular joint clicking?

Simon Olliver, Jonathan Broadbent, Murray Thomson, Mauro Farella

The relationship between dental malocclusion and temporomandibular disorders (TMDs) remains controversial. We aimed to investigate whether there is an association between posterior cross-bite in adolescence and self-reported temporomandibular joint (TMJ) clicking later in life, by analysing data from the Dunedin Multidisciplinary Health and Development Study. This is a longitudinal study of a birth cohort of 1037 children born in Dunedin, New Zealand between April 1972 and March 1973. Posterior cross-bite was clinically assessed when atudy members were aged 15 years, and self-reported TMJ clicking (at least occasionally) was assessed at age 38. Cross-tabulations and logistic regression modelling were used to assess whether an association existed between posterior cross-bite and subsequent TMJ clicking. A total of 726 Study members (70% of the original cohort) were both dentally examined at age 15 and participated at age 38 years. One in three had received orthodontic treatment by the age of 26 years. 94 Study members (13%) had a unilateral or bilateral posterior cross-bite at age 15 years. Among those who had no posterior cross–bite at 15, 33% reported TMJ clicking at least occasionally by age 38 years, while it was 34% among those with a cross-bite at age 15. No association between cross-bite and TMJ clicking was observed, and this held after controlling for their history of orthodontic treatment. We conclude that posterior cross–bite in adolescence is not a risk factor for TMJ clicking by late thirties.

Three-dimensional analysis of lip changes in response to simulated maxillary incisor advancement

Joanne Au, Li Mei, Florence Bennani, Austin Kang, Mauro Farella

In order to investigate three-dimensional (3D) lip changes in response to advancement of maxillary incisors, incremental maxillary incisor advancement was simulated by placing wax of increasing thickness (+2mm, +4mm, +6mm) on the incisors of 20 participants, and the induced lip changes were recorded using 3D stereo-photogrammetry. The induced displacement of lip landmarks was quantified using 3D image analysis software. A large inter-individual variation in lip response to simulated incisor advancement was observed. A significant overall effect on 3D lip changes was found

Collaborations

Collaborators within the University of Otago

A/Prof Azam Ali (Department of Applied Sciences)
Dr Hamza Bennani (Department of Computer Science)
Dr Claire Cameron (Department of Preventive & Social Medicine)
A/Prof George Dias (Department of Anatomy)
Julia Horsfield (Department of Pathology)
Prof Barbara Galland (Department of Women's and Children's Health)
Dr Louise Mainvil (Department of Human Nutrition)
A/Prof Tony Merriman (Department of Biochemistry)
A/Prof Michael Paulin (Department of Zoology)
Prof. Steven Robertson (Department of Women's and Children's Health)
Prof Rachel Taylor (Department of Medicine)
Dr Louise Mainvil (Department of Human Nutrition)

The research group actively collaborates with other renowned scientific groups within the University of Otago such as:

- Center for Bioengineering and Nanomedicine
- Department of Anatomy
- Department of Chemistry
- Department of Computer Science
- Department of Human Nutrition
- Department of Medicine
- Department of Psychology
- Department of Zoology
- Genetics Otago
- Neuroscience Programme
- Otago Zebrafish Facility

Collaborators at other institutions

A/Prof Mithran Goonewardene (University of Western Australia)
A/Prof Paul Schneider (University of Melbourne)
Professor Craig Dreyer (University of Adelaide)
Professor Ali Darendeliler (University of Nanjing)
Professor Kenji Fushima (University of Kanagawa)
Professor Noriaki Yoshida (University of Nagasaki)
Professor Huang Li, Dr Jialing Li, Dr Mary Ma (University of Nanjing)
Prof Alan Brook (University of Adelaide)
Dr Iacopo Cioffi (University of Toronto)
Jie Fang (Sichuan University)
Prof Luigi Gallo (University of Zurich)
A/Prof David Healey (University of Brisbane)
Jialing Li (Nanjing Medical University, China)
Prof Ambra Michelotti (University of Naples, Federico II)
Prof Sandro Palla (University of Zurich)

The programme also collaborates with the New Zealand Biomouth Research Group, and internationally works closely with the Department of Neuroscience at the University of Naples Federico II (Italy) and the Laboratory for Jaw Biomechanics at the University of Zurich (Switzerland).

Key funding successes

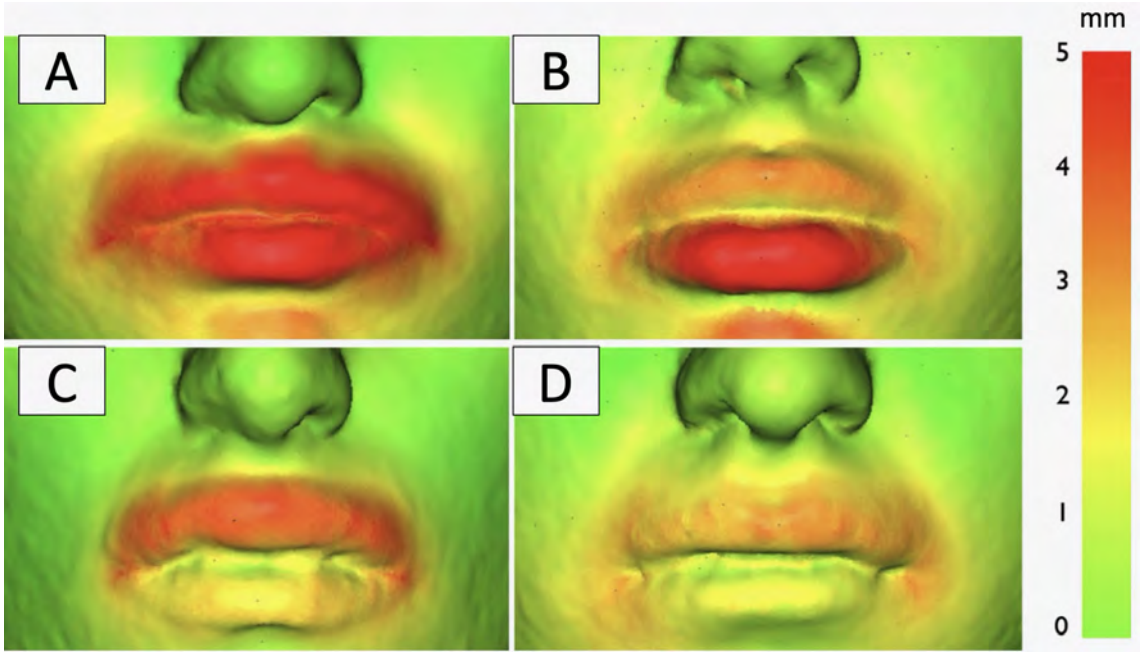
Lottery Health. Equipment Grant. Zygo ZeGage Pro 3D Optical Surface Profilometer. (Firth F and others) $ 124,121

New Zealand Dental Research Foundation. Effect of passive clear aligners on masticatory muscle activity in adults with and without oral parafunction. (Farella M and others) $ 10,000

New Zealand Dental Research Foundation. Patients' experiences with orthodontic treatment through traditional fixed appliances, clear aligners and direct-to-consumer clear aligners: a qualitative study. (Firth F and others) $ 10,000

Colgate Grant. What's in a smile? Impact of oral health on smiling features. (Farella M and others) $ 40,000

CureKids Innovation Seed A novel approach for monitoring eating behavior in children" (Farella M and others) $49,458



Examples of colour-coded scalar fields from four different female participants (A,B,C,D) with + 6 mm of incisor advancement Green areas correspond to areas of little to no change (-0.5 mm to 0.5 mm); yellow and red correspond to increasingly positive values of displacement. Note the large interindividual difference in soft tissue response.

for increasing values of simulated incisor advancement, as well as significant differences between anatomical landmarks of the lip. Maxillary incisor advancement significantly affects upper lip change in three planes of space; particularly, the anteroposterior plane, in which the response to simulated advancement appears to be non-linear.

Other craniofacial research projects

- What's in a smile? Impact of oral health on smiling features
- Effect of passive clear aligners on masticatory muscle activity in adults with and without oral parafunction
- Patients' experiences with orthodontic treatment through traditional fixed appliances, clear aligners and direct-to-consumer clear aligners: a qualitative study
- Effect of orthodontic extractions on face profile
- Modulation of bone related mediators in osteoblasts and periodontal ligament cells
- Can aligners move roots? Let's torque about it
- The psychological effect of malocclusion over the life course
- Development of an ovine model to investigate orthodontic tooth movement
- Impact of psychological and genetic factors on orthodontic pain
- Management of biofilm formation with Air-Flow in patients with fixed orthodontic appliances
- A novel approach for monitoring eating behavior in children
- Relationship between sugar sweetened drinks, tooth wear and dental caries in Māori
- Jaw muscle overload as a possible cause of orofacial pain
- Assessing three-dimensional tooth movements during orthodontic activations using an E-typodont
- The effect of mechanical strain on the unfolded protein response of periodontal ligament cells in a three-dimensional culture
- Predictive factors of orthodontic pain
- Efficacy of a mandibular advancement appliance on sleep disordered breathing in children
- A new approach to engineering 3-dimensional constructs of human bone matrix in a mechanically-active environment
- Genetic and environmental factors associated with hypodontia
- Biofilm management with oral probiotics in orthodontic patients: a triple-blind randomised placebo-controlled trial
- Genetics aspects of the long face