Craniofacial Research

Programme leader

Professor Mauro Farella

Deputy Programme Leader: Dr Joseph Antoun

Programme overview

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.

Dr Li Mei, Professor Mauro Farella, Danielle Hodgkinson and Dr Austin Kang.

KEY PERSONNEL

Staff

Professor Mauro Farella
Dr Joseph Antoun
Florence Bennani
Prof Richard Cannon
A/Prof Rohana De Silva
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Dr Hannah Jack
Dr Austin Kang
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A/Prof Geoffrey Tompkins
A/Prof Jonathan Broadbent
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A/Prof Nick Heng
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Postgraduate students

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PhD students

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Collaborations

University of Otago

Dr Azam Ali (Applied Sciences)
Hamza Bennani (Computer Science)
Dr Claire Cameron (Preventive & Social Medicine)
A/Prof George Dias (Anatomy)
A/Prof Julia Horsfield (Pathology)
A/Prof Barbara Galland (Women's and Children's Health)
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A/Prof Michael Paulin (Zoology)
A/Prof Sylvia Sander (Chemistry)
Prof Steven Robertson (Women's and Children's Health)
Center for Bioengineering and Nanomedicine
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Neuroscience Programme
Otago Zebrafish Facility

National

New Zealand Biomouth Research Group

International

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Prof Luigi Gallo (University of Zurich)
A/Prof David Healey (University of Brisbane)
Dr Jialing Li (Nanjing Medical University)
Prof Ambra Michelotti (University of Naples, Federico II)
Prof Sandro Palla (University of Zurich)

Current research

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

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

Aim: To: 1) collect objective data on masticatory muscle activity during wake-time in the natural environment using a smart-phone assisted wireless electromyographic (EMG) device; and 2) compare the features of masticatory muscle activity between females with myogenous temporomandibular disorder (TMD) and age-matched pain-free controls.

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. 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 Aim #2, EMG activity was collected in females with myogenous TMD and age-matched pain-free controls while performing their normal routine activity over two consecutive days. Contraction episodes were detected at three thresholds: 3, 5 and 10 per cent of maximum voluntary contraction (MVC). The frequency, duration and amplitude of masseter contraction episodes were calculated and compared across groups and conditions using intraclass correlation coefficients (ICC) and mixed model analysis.

The wireless device reliably detected masseter muscle contraction episodes under both laboratory and natural environment conditions. Most masseter contraction episodes during normal routine were of low amplitude (<10% of

MVC) and short duration (<10 seconds). A significant difference in total jaw contraction time (%) was found between groups, with longer contractions in the TMD pain group. No significant association was found between self-reported parafunction and masticatory muscle activity.

Conclusions: Myogenous TMD patients contract the masseter for longer than pain-free controls. Smart-phone assisted monitoring of the jaw muscles represents a promising tool to investigate oral behaviour patterns in orthodontic patients.

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

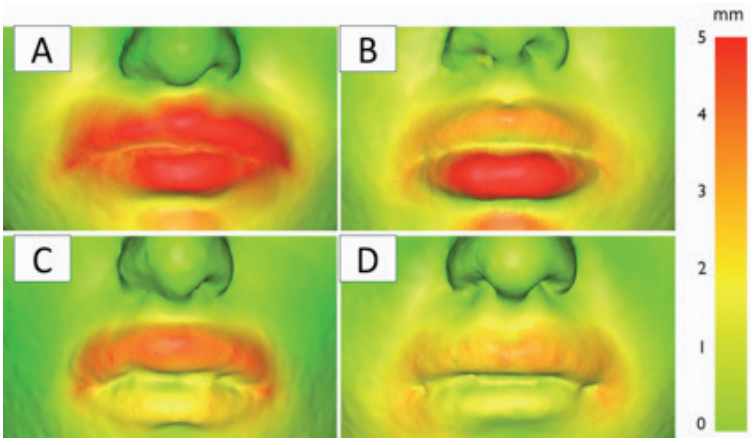
Investigators: Joanne Au, Li Mei, Florence Bennani, Austin Kang, Mauro Farella

Aim: To assess three-dimensional (3D) lip changes in response to simulated maxillary incisor advancement.

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. Data was analysed using a repeated-measures analysis of variance (ANOVA).

A large inter-individual variation in lip response to simulated incisor advancement was observed. A significant overall effect on 3D lip changes was found for increasing values of simulated incisor advancement as well as significant differences between anatomical landmarks of the lip. Most points moved outwards and antero-superiorly, except the midpoint and corners of the lip. Greatest movement was observed in the sagittal plane, followed by vertical and transverse planes.

Conclusions: 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.



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.

Is posterior crossbite a risk factor for temporomandibular joint clicking?

Investigators: Simon Olliver, Jonathan Broadbent, Murray Thomson, Mauro Farella.

Aim: The relationship between dental malocclusion and temporomandibular disorders (TMDs) remains controversial. The aim of this study was to investigate the putative association between posterior cross-bite in adolescence and self-reported temporomandibular joint (TMJ) clicking later in life.

The Dunedin Multidisciplinary Health and Development Study is a longitudinal study of a birth cohort of 1037 children born in Dunedin, New Zealand between April 1972 and March 1973. Health and development data have been collected periodically since then. Posterior cross-bite was clinically assessed when Study 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 dentally examined at age 15 and also participated at age 38 years. One in three had received orthodontic treatment by the age of 26 years. A total of 94 Study members (13%) had a unilateral or bilateral posterior cross-bite at age 15 years. Among those whohad 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.

Conclusions: Posterior cross–bite in adolescence is not a risk factor for TMJ clicking by the late thirties.

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

Investigators: 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.

Conclusions: 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.

Funding highlights

Total research funding (external) obtained in the period 2017- 2018 amounted to $266,311.

Funding highlights 2017-18:

Colgate SJWRI Research Grant. Development of novel bovine derived hydroxyapatite toothpaste for caries prevention (Cathro P, Ratnayake J, Mei L, Guan G, Dias GJ) $13,423

University of Otago Research Grant. I just want my teeth straightened. (LF Page, JS Antoun, PW Fowler, HC Jack) $36,000

Ministry of Oral Health Research Fund. Reading between the lines: how do young New Zealanders from lower socio-economic backgrounds feel about not getting their teeth straightened? (LF Page, JS Antoun, HC Jack) $29,000

Ministry of Oral Health Research Fund. Efficacy of the oral probiotic Streptococcus salivarius in managing bio lm formation in patients wearing xed orthodontic appliances (Li Mei, Gareth Benic, Mauro Farella, Nick Heng) $11,410

CureKids Innovation Seed. A novel approach for monitoring eating behavior in children (Mauro Farella, Ghassan Idris, Barbara Galland, Rachel Taylor, Claire Smith) $49,458

Other Craniofacial Research projects include:

- Effect of orthodontic extractions on face profile.
- 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
- A novel model for exploring the causes and treatments of craniofacial birth defects
- Biofilm management with oral probiotics in orthodontic patients: a triple-blind randomised placebo-controlled trial
- Genetics aspects of the long face
- Growth factor expression in the rat condyle: implications for craniofacial development
- Intra-oral monitoring of oral pH and bruxism

MedTech CoRE Grant-in-Aid. EMG-Guard: a smart-phone assisted wireless EMG device for small superficial muscles. (Mauro Farella, Michael Paulin, Richard Cannon, Maggie-Lee Huckabee) $25,000.

New Zealand Dental Research Foundation. Development of an ovine model for investigating effects of orthodontic tooth movement (Rachel Farrar, Mauro Farella, Warwick Duncan, Joseph Antoun, Birte Melsen) $15,000.

New Zealand Dental Research Foundation. Do orthodontic extractions ruin faces? (Danielle Hodgkinson, Mauro Farella, Joseph Antoun, Li Mei, Austin Kang) $11,654

New Zealand Dental Research Foundation. Effects of different adhesive removal methods on bacterial colonization on in vivo orthodontic bracket model (Ana Low, Joseph Antoun, Li Mei, Geoffrey Tompkins, Mauro Farella) $11,965.

Key publications

Chen, L., Liversidge, H., Chen, K., Farella, M., Sassani, S., Patel, D.,Brook, A. (2018). Delay in dental development and variations in root morphology are outcomes of the complex adaptive system associated with the numerical variation of hypodontia. International Journal of Design & Nature & Ecodynamics, 13(1), 101-106

Sew Hoy, W., Antoun, J., Lin, W., Chandler, N., Merriman, T., & Farella, M. (2018). Ecological momentary assessment of pain in adolescents undergoing orthodontic treatment using a smartphone app. Seminars in Orthodontics. Advance online publication.

Ma, R., Hwang, K.-C., Murray, C., Thomson, W. M., Farella, M., & Mei, L. (2018). Clinical dental noise and its association with the hearing thresholds of New Zealand dental students and clinical staff. New Zealand Dental Journal, 114(2), 73-78.

Jiang Q, Li J, Mei L, Du J, Levrini L, Abbate GM, Li H. Periodontal health during orthodontic treatment with clear aligners and fixed appliances: a meta-analysis. Journal of the American Dental Association. 2018;149(8):712-720.e12.

Wang S, Lin H, Yang Y, Zhao X, Mei L, Zheng W, Li Y, Zhao Z. Use of autonomous maximal smile to evaluate dental and gingival exposure. Korean J Orthod. 2018 May;48(3):182-188.

Wang Y, Li J, Sun W, Li H, Cannon RD, Mei L. Effect of non-fluoride agents on the prevention of dental caries in primary dentition: A systematic review. PLoS One. 2017 Aug 7;12(8):e0182221.

Jin C, Bennani F, Gray A, Farella M, Mei L. Survival analysis of orthodontic retainers. Eur J Orthod. 2018 Sep 28;40(5):531-536.

Al-Dujaili M, Milne TJ, Cannon RD, Farella M. Postnatal expression of chondrogenic and osteogenic regulatory factor mRNA in the rat condylar cartilage. Arch Oral Biol. 2018 Sep;93:126-132.

Idris G, Galland B, Robertson CJ, Gray A, Farella M. Mandibular advancement appliances for sleep-disordered breathing in children: A randomized crossover clinical trial. J Dent. 2018 Apr;71:9-17.

Nichols GAL, Antoun JS, Fowler PV, Al-Ani AH, Farella M. Long-term changes in oral health-related quality of life of standard, cleft, and surgery patients after orthodontic treatment: A longitudinal study. Am J Orthod Dentofacial Orthop. 2018 Feb;153(2):224-231.

Mei L, Chieng J, Wong C, Benic G, Farella M. Factors affecting dental biofilm in patients wearing fixed orthodontic appliances. Prog Orthod. 2017 Dec;18(1):4.

Al Balushi, S., Mei, L., & Farella, M. (2017). Patient's satisfaction with orthodontic care from an academic clinical service. New Zealand Dental Journal, 113(4), 13-20.

Al-Ani AH, Antoun JS, Thomson WM, Merriman TR, Farella M. Maternal Smoking during Pregnancy Is Associated with Offspring Hypodontia. J Dent Res. 2017 Aug;96(9):1014-1019.

Ukra A, Foster Page LA, Thomson WM, Knight RG, Farella M. Self-report of temporomandibular joint clicking and psychological factors: is there an association? J Oral Rehabil. 2017 Jul;44(7):511-516

Antoun JS, Mei L, Gibbs K, Farella M. Effect of orthodontic treatment on the periodontal tissues. Periodontol 2000. 2017 Jun;74(1):140-157.

Hutchinson EF, Farella M, Hoffman J, Kramer B. Variations in bone density across the body of the immature human mandible. J Anat. 2017 May;230(5):679-688.

Cioffi I, Farella M, Chiodini P, Ammendola L, Capuozzo R, Klain C, Vollaro S, Michelotti A. Effect of weather on temporal pain patterns in patients with temporomandibular disorders and migraine. J Oral Rehabil. 2017 May;44(5):333-339.

Antoun JS, Thomson WM, Merriman TR, Rongo R, Farella M. Impact of skeletal divergence on oral health-related quality of life and self-reported jaw function. Korean J Orthod. 2017 May;47(3):186-194.

Meredith L, Farella M, Lowrey S, Cannon RD, Mei L. Atomic force microscopy analysis of enamel nanotopography after interproximal reduction. Am J Orthod Dentofacial Orthop. 2017 Apr;151(4):750-757.

Chan A, Antoun JS, Morgaine KC, Farella M. Accounts of bullying on Twitter in relation to dentofacial features and orthodontic treatment. J Oral Rehabil. 2017 Apr;44(4):244-250.

Al-Ani AH, Antoun JS, Stacknik S, Farella M. Management of missing mandibular second premolars: a review. Aust Orthod J. 2017 Feb;Spec No:87-98.

Al-Ani AH, Antoun JS, Thomson WM, Merriman TR, Farella M. Hypodontia: An Update on Its Etiology, Classification, and Clinical Management. Biomed Res Int. 2017;2017:9378325.

Antoun JS, Thomson WM, Merriman TR, Farella M. Self-reported oral behaviour habits in hyperdivergent and normodivergent facial types. J Oral Rehabil. 2017 Jan;44(1):16-21.

Meredith, L., Mei, L., Cannon, R. D., & Farella, M. (2017). Interproximal reduction in orthodontics: Why, where, how much to remove? Australasian Orthodontic Journal, 33(2), 150-157.

He D, Mei L, Wang Y, Li J, Li H. Association between maxillary anterior supernumerary teeth and impacted incisors in mixed dentition. Journal of the American Dental Association. 2017;148(8):595-603.

Wang Y, Li J, Sun W, Li H, Cannon RD, Mei L. Effect of non-fluoride agents on the prevention of dental caries in primary dentition: A systematic review. PLoS ONE. 2017;12 (8):e0182221.

Wen J, Liu S, Ye X, Xie X, Li J, Li H, Mei L. Comparative study of cephalometric measurements using three imaging modalities: 2D lateral cephalometric radiography, 2D CBCT-generated cephalogram and 3D CBCT. Journal of the American Dental Association. 2017;148:913-921.