

Biomechanics and Oral Implantology

Programme Directors – Associate Professor Neil Waddell and Professor Warwick Duncan

Our work has two main themes, biomechanics and oral implantology. Within the area of biomechanics we conduct experimental and observational research in:

- Dental materials – development of new dental restorative materials for dental CAD/CAM systems.
- Silver and gold nanomaterial technology group – developing nanoparticles for use in a range of therapeutic technologies and toughening of advanced ceramics.
- Cranio-facial biomechanics – prosthodontic failure mechanisms and adhesion of dental restorations and materials.
- Sub-concussive brain injury research – *in vitro* modelling of the effects of blunt force trauma to the head on accumulative damage to the brain.
- Dental hard tissues and evolutionary oral biology – using animal teeth to gather a wide range of information about the biology, evolution and interactions with the environment of fossil and recent species.
- Forensic biology – *in vitro* modelling of blunt force trauma, forensic odontology, wounding and ballistic blood splatter analysis, development of simulant materials for forensic modelling.
- Communication of forensic concepts to the general public

Within the area of oral implantology our research focuses on:

- Bone replacement grafting
- Stem-cell regenerative therapies.
- Early diagnosis and treatment of peri-implant immune-inflammatory disease
- Fit of aftermarket versus original equipment manufacturer (OEM) implant components
- Modifications to dental implant materials and surfaces to enhance osseointegration.
- The effects of implant fixture corrosion products on periodontal structures.
- *In vitro* modelling of masticatory forces on implant overdentures, their supporting sub-structures and surrounding bone.
- The short-term and long-term clinical outcomes of modified surgical and prosthodontic loading protocols during implant treatment.

Key personnel and collaborations

Staff

Professor WJ Duncan
Professor KM Lyons
Professor P Brunton
Associate Professor JN Waddell
Professor DC Tong
Dr P Cathro
Dr DR Schwass
Associate Professor A Tawse-Smith
Dr S Ma
Ms S Hanlin
Dr C Loch Santos Da Silva
Dr KC Li
Mr L Jansen van Vuuren
Mrs. W Jansen van Vuuren
Ms J Choi

Postgraduate students

Andrew Tawse-Smith	Vanda Symon
Donald Schwass	Seung David Ko
Joanne Choi	Leonid Khimovich
Mohammed Alrashed	James Dawson
Sunyoung Ma	Yevgeny Sheftel
Therese De Castro	Frances Ruddiman
Ludwig Jansen van Vuuren	Allauddin Siddiqi
Veivakatorocaketaki Masi Ovini	Gemma Cotton
Abdullah Barazanchi	Anne-Christine (Anki)
Lisa Falland	Lindstrom

Our work involves a multi-disciplinary approach and we collaborate with a wide group of researchers within; the Faculty of Dentistry; the University of Otago (Department of Geology, Department of Chemistry, Department of Anatomy and Structural Biology, Department of Zoology, Department of Marine Sciences); nationally (Department of Mechanical Engineering, University of Canterbury, Van Der Veer Institute, University of Canterbury, Department of Engineering Sciences, Auckland University, Forensic Science Department of Environmental Science and Research, South Island Brain Injury Research Group (SIBIRG)) and internationally (University of Adelaide School of Dentistry, Impact and Armour Group, Cranfield University/Defence Academy of the United Kingdom, Shrivenham, University of the Witwatersrand, Johannesburg, South African Nuclear Energy Corporation in Palindaba, Tokyo University of Agriculture and Technology, Tokyo).

Current research

Activity 1. Dental Materials.

Description: Evaluating specific issues associated with the range of dental materials from composite resin systems to advanced ceramics. One of the groups has a focus on mechanical properties of dental ceramics and their reasons for failure, with a particular interest in fractography and analysis of failure in brittle materials. A more recent novel area is the silver and gold nanomaterial technology group, which is developing nanoparticles for use in a range of therapeutic technologies and toughening of high strength ceramics.

Aim: Provide basic information about these materials that enables a better basis for understanding their usage in clinical settings and the development of new treatment technologies and materials.

Source(s) of funding: Neurological Foundation Research Grant, Maurice and Phyllis Paykel Trust, ANZAOMS Research and Education Trust, New Zealand Dental Association Research Foundation, Fuller Scholarship for Dentistry, Otago Innovation, University of Otago Research Grant, Sir John Walsh Research Institute and proprietary funding.

Activity 2. Sub-concussive Brain Injury

Description: Concussive and subconcussive injury is a global phenomenon, which has been likened to a silent epidemic due to the large numbers of young people who sustain head injuries in sports and military activities. The objective of this research is to quantify the impact forces transmitted through the various levels of scalp, skull and brain at values below what is predictive of concussion. Once this data is obtained, clinical evaluations of neurologic function using

established methodology can be used to correlate the effects of these impact forces for further research, but the main objective for this research study is the quantification of these forces.

Aim: Can the impact forces involved with subconcussive head injury be quantified in order to determine a threshold or range of impact forces that may be predictive of sub-concussion?

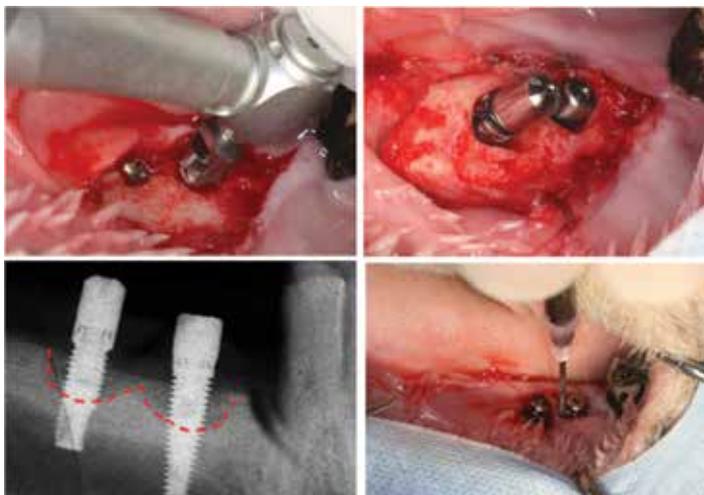
Source(s) of funding: Neurological Foundation Research Grant, Maurice and Phyllis Paykel Trust, University of Otago Research Grant. University of Otago Health Sciences Division Sandpit Funding Grant. ANZAOMS Research and Education Trust.

Activity 3. Soft and Hard Tissue Biomechanics and Forensic Biology

Description: Investigating the basic properties of skin, teeth and bone related to the craniofacial region and forensic issues.

Aims: Teeth and bone are special in that they preserve a record of their formation in the adult end-product. Hence, an examination of adult morphology can be used to reveal some of the processes that were involved, as well as some of the perturbations of such processes. This knowledge can then be linked to clinical findings that will (hopefully) result in better therapeutic outcomes. Our research has mainly been focused on the structure and function of enamel in different species, the forces generated during swallowing, and the behaviour of skin and bones during events such as ballistic and blunt force trauma.

Sources of funding: New Zealand Dental Association Research Foundation, United States Department of Justice, ESR Capability Development Fund.



Nanosilver gel treatment of ligature-induced peri-implantitis in a sheep model (W Duncan, A Siddiqi, D Schwass, C Meledandri, G Cotton, C da Silva).



Biomet 3i Implant in sheep femur model with Endobon bone replacement graft & Osseoguard collagen membrane

Biomet 3i implant in sheep femur model with Endobon bone replacement xenograft and Osseoguard resorbable collagen membrane (W Duncan, P Schmidlin, J Liu).

Activity 4. Oral Implantology and Associated Superstructures

Description: Our research teams have expertise with respect to conducting clinical (human) and preclinical (animal) trials and laboratory-based research relating to oral implants. Currently, funded research is being conducted into different oral implant systems, materials, surfaces, superstructures, and surgical and restorative protocols, as well as into supporting biological and regenerative products. Our research encompasses immediate placement and/or loading of single implants and implant-supported overdentures, fit of zirconia prostheses, implant analysis using micro-CT, *in vitro* modelling of strain distribution within implant overdentures and their supporting substructures and bone, and *ex vivo* analysis of implant fixture corrosion. Commercially-sponsored research ranges from comparisons of different implant systems, to different bone replacement grafts and resorbable membranes in sheep animal models including mandibular tooth extraction sockets, femur epicondyle and maxillary sinus. We have also recently established a new animal model of peri-implantitis for investigating novel therapeutic agents.

Aims: Evidence-based treatment that reduces the interval between oral implant placement and loading by optimising the implant design and the surgical and prosthodontic protocols and materials. Diagnosis and treatment of peri-implant immunoinflammatory disease.

Source(s) of funding: New Zealand Dental Association Research Foundation; JF Fuller Foundation; International Team for Oral Implantology ITI Switzerland; Straumann AG, Switzerland; Nobel Biocare Australia; Southern Implants, South Africa; Otago Innovation Ltd; Zimmer Biomet 3i Ltd, United States of America; Resorba GmbH, Germany; Geistlich Pharma Ltd, Switzerland; Ministry of Business, Innovation and Employment, New Zealand; Maurice and Phyllis Paykel Trust; University of Otago Research Grants.

Research funding (over \$5000)

\$12,000 Waddell JN, Falland L, Tong D & Brunton P. Neurological Foundation Research Grant 1624-SPG, Development of skin/skull/brain model to measure impact forces to the head and brain-injury mechanisms.

\$999,804 Duncan WJ, CI – Smith M, Meledandri C and Waddell JN. MBIE's 2016 Endeavour Round – Smart Ideas. "Silverbone" - Otago's nano-silver technology plus NZ-manufactured bone graft produces unique antibacterial biomaterial.

\$8,000 Jansen van Vuuren L, CI – Duncan WJ & Waddell JN. New Zealand Dental Association Research Fund. Development of a simulant model for clinically relevant testing of implant and natural tooth supported all-ceramic restorations.

\$30,026 Loch C & Cannon R, CI – Waddell JN & Brunton P. MBIE, 2016 Unlocking Curious Minds Fund – Local.

\$1,200,000 Duncan WJ and Harris P, CI – Chandler NP and Waddell JN. UltraD3: Ultrasonic Dental Diagnostic Device, MBIE Targeted Research Grant.

\$5,000 Choi J, Waddell JN & Lyons K. New Zealand Dental Association Research Fund. Continuous measurement of intraoral pH and temperature of individuals with and without xerostomia.

\$7000 Waddell JN, Falland L, Tong D & Brunton P. Maurice and Phyllis Paykel Trust, Development of a skin/skull/brain model to measure impact forces to the head and brain injury mechanisms.

\$12,000 Waddell JN, Li KC, Meledandri C, Prior D & Lyons K. New Zealand Dental Association Research Fund. Gold nanoparticle reinforcement of biomedical dental ceramics.

\$35,591 Tong DC, Waddell JN, Bennett AC: Quantification of impact forces in the prevention of sub-concussive head injury using a forensic head model. University of Otago Research Grant.

\$11,380 Tong DC, Waddell JN, Winter T, Bennett AC: Quantification of impact forces to the head using a forensic model. ANZAOMS Research and Education Trust.

\$21,000 Schwass D, Meledandri CJ. Pre-seed funding support from Otago Innovation.

\$40,000: Duncan W – CI, Chandler NP and Waddell JN: A large animal gum-disease model of peri-implantitis and periodontitis in sheep for testing novel treatment strategies. University of Otago Research Grant (UORG).

\$18,000: Duncan W: The Machined Surface Coronal implant in a sheep model of peri-implantitis. Southern Implants Ltd SA.

\$64,400 Schwass D, Meledandri CJ. Evaluating the efficacy of a topical antimicrobial gel formulation for treating peri-implantitis in a sheep model. University of Otago Research Grant.

\$66,340 Duncan WJ and Schmidlin P, Evaluation of novel bone replacement grafts in a sheep animal model. Resorba Medical GmbH, Germany.

\$156,000. Duncan WJ and Schmidlin P, Evaluation of novel bone replacement grafting products for tooth socket preservation and maxillary sinus elevation in a sheep animal model. Zimmer Biomet 3i, United States of America.

\$10,000, Duncan WJ, Coates D, Ye Naung N, Zannicotti D, De Silva RK. Maurice and Phyllis Paykel Trust.