

Practical Procedures in Dental Occlusion

*To my 2Ms: my wife Manal and son in law Mohsi
To my 3Ls: my daughters Loujin, Lilas and Leanne*

Ziad Al-Ani

*To the Creator, My Mother and Father, Wife Azmat and my 4 children Zayd, Adam, Esa,
Khadijah*

Riaz Yar

Practical Procedures in Dental Occlusion

*Ziad Al-Ani, BDS, Oral Surg PG Dip, Fixed Pros PG Dip, PGCAP, MSc, PhD, MFDS RCS(Ed), FHEA, RET Fellow
Senior Lecturer
School of Medicine, Dentistry & Nursing
University of Glasgow, UK*

*Riaz Yar, BDS, MFDS RCS (Edin), MPhil (Restorative), DPDS, Dip Implant Dent RCS (Edin), MPros Dent RCS (Edin), FDS RCS (Edin), Masters in Soft Tissue around Teeth and Implants (Bologna)
Director and Visiting Professor
The Square Advanced Dental Care
Hale Barns, UK*

WILEY Blackwell

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by law. Advice on how to obtain permission to reuse material from this title is available at <http://www.wiley.com/go/permissions>.

The right of Ziad Al-Ani and Riaz Yar to be identified as the authors of this work has been asserted in accordance with law.

Registered Offices

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office

9600 Garsington Road, Oxford, OX4 2DQ, UK

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Limit of Liability/Disclaimer of Warranty

The contents of this work are intended to further general scientific research, understanding, and discussion only and are not intended and should not be relied upon as recommending or promoting scientific method, diagnosis, or treatment by physicians for any particular patient. In view of ongoing research, equipment modifications, changes in governmental regulations, and the constant flow of information relating to the use of medicines, equipment, and devices, the reader is urged to review and evaluate the information provided in the package insert or instructions for each medicine, equipment, or device for, among other things, any changes in the instructions or indication of usage and for added warnings and precautions. While the publisher and authors have used their best efforts in preparing this work, they make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives, written sales materials or promotional statements for this work. The fact that an organization, website, or product is referred to in this work as a citation and/or potential source of further information does not mean that the publisher and authors endorse the information or services the organization, website, or product may provide or recommendations it may make. This work is sold with the understanding that the publisher is not engaged in rendering professional services. The advice and strategies contained herein may not be suitable for your situation. You should consult with a specialist where appropriate. Further, readers should be aware that websites listed in this work may have changed or disappeared between when this work was written and when it is read. Neither the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

Library of Congress Cataloging-in-Publication Data

Names: Al-Ani, M. Ziad, author. | Yar, Riaz, author.

Title: Practical procedures in dental occlusion / Ziad Al-Ani, Riaz Yar.

Description: First edition. | Hoboken, NJ : John Wiley & Sons, 2022. |

Includes bibliographical references and index.

Identifiers: LCCN 2021013458 (print) | LCCN 2021013459 (ebook) | ISBN

9781119678519 (paperback) | ISBN 9781119678489 (adobe pdf) | ISBN

9781119678526 (epub)

Subjects: MESH: Dental Occlusion | Malocclusion--prevention & control |

Orthodontics, Corrective--methods

Classification: LCC RK523 (print) | LCC RK523 (ebook) | NLM WU 440 | DDC

617.6/43--dc23

LC record available at <https://lccn.loc.gov/2021013458>

LC ebook record available at <https://lccn.loc.gov/2021013459>

Cover Design: Wiley

Cover Image: © Ziad Al-Ani

Set in 9.5/12.5pt STIXTwoText by Straive, Pondicherry, India

Contents

Acknowledgements *vii*
About the Companion Website *viii*
About the Book *ix*

- 1 Terminology** *1*
- 2 Neuroanatomy – Why is It Important?** *3*
- 3 What's of Use to Me in Practice? Armamentarium, Equipment and Techniques** *13*
- 4 I Don't Know What I Am Recording. Where Are the True Contacts?** *44*
- 5 The Crown is High** *55*
- 6 My Bite Feels Different** *68*
- 7 'My Front Tooth Filling Keeps Fracturing'** *73*
- 8 TMD and Occlusion – Is There a Link?** *83*
- 9 How Would I Adjust a High Occlusal Contact?** *88*
- 10 How Would I Ensure a Good Occlusion on Posterior Composite Restorations?** *97*
- 11 My Front Teeth Feel Loose and Are Moving** *103*
- 12 Canine Guidance or Group Function?** *109*
- 13 Replacing Missing Teeth – Abutment is Involved with Guidance** *121*

14	The Space is Lost! Loss of Occlusal Space Following Crown Prep	124
15	My Front Teeth are Worn	129
16	All My Teeth Are Restored But Don't Meet Like They Did Before	153
17	I Am Breaking My Teeth and Veneers and Lost a Tooth Due to Grinding	168
18	Occlusion on Implants. Any Difference?	179
Glossary of Terms 194		
Short Answer Questions 206		
Index 208		

Acknowledgements

The authors wish to acknowledge the kind permission of Claire O'Connor, Neil Sparkes and Deborah Khadem in using them as photographic models in some chapters of this book.

We are very grateful to Tanya McMullin, Loan Nguyen and Bhavya Boopathi for their advice and support in the production of this text.

We would like to thank Mr Robert Gandy, Ceramist, The Cube Advanced Dental Laboratory for the Wax up on the front page and all the ceramic restorations documented in the book.

About the Companion Website

Don't forget to visit the companion website for this book:

www.wiley.com/go/al-ani-and-riaz/dental-occlusion



There you will find valuable material designed to enhance your learning, including:

- Videos
- Figures from the book as downloadable PowerPoint slides



About the Book

The subject of occlusion has traditionally been very difficult to learn, understand and manage. As a result, an unwanted mystique has been built around it that has intimidated a large part of the dental profession.

It is now more important than ever that dental practitioners familiarise themselves with a subject that so intimately affects their daily professional lives.

Restorative treatment outcome is highly dependent on the occlusion of the restoration when the treatment is complete and therefore sound up-to-date knowledge of all evidence-based aspects of this commonly encountered condition is essential.

General practitioners usually have very limited practical clinical experience in occlusion and most of the books available for them are theory-based resources.

This book aims to enable readers to gain a solid foundation of knowledge of occlusion, by providing practical, learnable, usable information and techniques which are demonstrated in a practical and easy-to-understand style. The intention is to explain current evidence-based practical concepts in the field of dental occlusion so that they can be reflected in the reader's clinical practice.

The book contains a series of everyday clinical situations in occlusion, that may be encountered in general practice, to help readers understand and engage with the information and to promote effective clinical management.

It aims to provide practical guidance to what is required to optimise restorative treatment outcomes, including occlusion, in simple and advanced restorative care. The book also promotes learning as a dynamic process of active involvement. It encourages valuation by self-assessment with questions at the end of the book.

Chapter 1 – Terminology

It is important we address terminology right at the start to reduce the confusion that has been created throughout the history of occlusion. As a source, Glossary of Prosthodontic Terms 2017 edition is used throughout the book.

Chapter 2 – Neuroanatomy – Why is It Important?

This chapter will address neuromuscular philosophies and introduce the neurolink between all systems from the periodontal mechanoreceptors on teeth through to central pattern generators in the pons and muscles and temporomandibular harmony.

Chapter 3 – What’s of Use to Me in Practice? Armamentarium, Equipment and Techniques

This is a ‘how-to’ chapter. It is important for the clinician to know the equipment and techniques used in occlusal examination, registration and record. This chapter also discusses facebow, articulators and how to make a stabilisation splint.

Chapter 4 – I Don’t Know What I Am Recording Where are the True Contacts?

This chapter illustrates a classic problem most of the practitioners face when recording occlusal contacts using different articulating papers. It will highlight the following:

- morphology and type of occlusal contacts in class 1, class 2 and class 3 relationships
- the importance of selecting the correct size of articulating papers
- the appropriate techniques in recording occlusal contacts
- how to properly mark shiny occlusal surfaces.

Chapter 5 – The Crown is High

This clinical scenario will highlight the possible factors which may contribute to this situation (a high crown). It discussed the importance of accurate opposing alginate impression and mounting of the casts. The laboratory handling of the cast and the provisional crown will be covered.

Chapter 6 – My Bite Feels Different

Using a clinical scenario of a change of patient bite following fitting of an indirect restoration, this chapter will mainly focus on the importance of adopting the conformative approach in restorative dentistry. The possibility of introducing iatrogenic changes to a patient’s bite is quite real and can have immediate consequences. Avoidance of the problem is the best approach but to do this, you must be aware of the potential pitfalls in restorative care.

Chapter 7 – My Front Tooth Filling Keeps Fracturing

This clinical scenario of a fractured upper central incisor composite restoration will highlight the importance of checking premature contacts in centric relation and dynamic occlusion.

Chapter 8 – TMD and Occlusion – Is There a Link?

Opinion regarding the importance of occlusion as an aetiological factor in the development of TMDs has shifted between it being the main causative factor and there being no correlation at all. This chapter will discuss this controversy and provides the reader with findings from contemporary literature.

Chapter 9 – How Would I Adjust a High Occlusal Contact?

This chapter will explain the proper techniques which should be adopted when adjusting the occlusal contacts and interferences by the dentist.

Chapter 10 – How Would I Ensure a Good Occlusion on Posterior Composite Restorations?

This chapter will illustrate the concepts and practical steps of achieving occlusal surfaces which provide proper reconstruction of natural morphology. It will highlight the following aspects:

- conforming to existing guidance in restored teeth
- creating departure clearance spaces
- the importance of the location of the occlusal contact.

Chapter 11 – My Front Teeth Feel Loose and Are Moving

This chapter will discuss occlusal trauma from functional or parafunctional forces. Lack of freedom in centric and the effect of RCP–ICP slide on anterior teeth will be also covered.

Chapter 12 – Canine Guidance or Group Function?

This has been an ongoing debate over many years with discussions on which lateral-based occlusal scheme is the best for the patient. This chapter will discuss the rationale behind both and how to achieve them clinically.

Chapter 13 – Replacing Missing Teeth – Abutment is Involved with Guidance

This clinical scenario will highlight the flowing points:

- checking the guidance prior to commencing treatment
- conforming to the guidance by selecting a treatment plan which avoids changing it.

Chapter 14 – The Space is Lost! Loss of Occlusal Space Following Crown Prep

This chapter will discuss the significant concepts which need to be understood and planned when considering restoration of a tooth involved in the centric relation/retruded contact position. How to manage when the space is suddenly lost during crown preparation on a tooth that is the last in the arch.

Chapter 15 – My Front Teeth Are Worn

Management of tooth surface loss is a complex treatment but some straightforward rules will help in diagnosis of the cause, monitoring of the situation and its management.

This chapter will illustrate the principles of management of non-carious tooth surface loss (TSL) cases and will focus on:

- achieving an appropriate OVD (when and how)
- review of mounted study casts
- diagnostic wax-up
- Dahl concept.

Chapter 16 – All My Teeth Are Restored But Don’t Meet Like They Did Before

In this chapter, a patient has presented with a restored mouth with multiple crowns and they feel the teeth do not meet like before. They cannot find a comfortable position. The use of material that allows testing the increase of OVD when managing advanced restorative care cases will be discussed. A full description of clinical procedure will be offered here.

Chapter 17 – I Am Breaking My Teeth and Veneers and Lost a Tooth Due To Grinding

The following points are discussed in this chapter:

- OVD increase
- improving incisal and occlusal relationships
- rule of thirds
- aesthetic and functional analysis.

Chapter 18 – Occlusion on Implants. Any difference?

Dental implants may be more prone to occlusal overloading. A primary cause of peri-implantitis and bone loss around implants is the excessive force applied from unwanted occlusal contact. The occlusal prescription of an implant-supported restoration, therefore, has to be much more carefully designed than that on a natural tooth. The 10 principles of occlusion over implants are discussed in this chapter.

Glossary of Terms

This is more of a dictionary of terms than merely a glossary of terms used in this book. This chapter isolates the relevant terms from the glossary of prosthodontic terms. published regularly in the Journal of Prosthetic Dentistry.

Short Answer Questions

This chapter includes short answer questions for the reader to practise. The knowledge gained from reading this book will enable the reader to answer these questions effectively.

1

Terminology

It is important we address terminology right at the start to reduce the confusion that has been created throughout the history of occlusion. As a source, we will use the Glossary of Prosthodontic Terms (GTP) (2017) edition for the most part.

The three most important terms are defined below.

Centric occlusion (CO) – the occlusion of opposing teeth when the mandible is in centric relation (CR); this may or may not coincide with the maximal intercuspal position (MICP) (GTP 2017). Throughout the literature (Jiménez-Silva et al. 2017, McNamara et al. 1995, Shildkraut et al. 1994, Weffort and de Fantini 2010), centric occlusion is also known as intercuspal or MICP and hence the confusion because the same term can indicate two different positions. So, to prevent further confusion, we will state that centric occlusion is MICP.

Centric relation – this position has five main points:

- 1) a maxillomandibular relationship, independent of tooth contact
- 2) the condyles articulate in the anterior-superior position against the posterior slopes of the articular eminences
- 3) the mandible is restricted to a purely rotary movement
- 4) from this unstrained, physiological, maxillomandibular relationship, the patient can make vertical, lateral, or protrusive movements
- 5) it is a clinically useful, repeatable reference position.

Each statement can be debated and to achieve consensus may be difficult, but the key point is that this is a tooth-independent position, i.e. it can be recorded in edentulous patients. We feel that first statement is incomplete, and would add: a maxillomandibular relationship, independent of tooth contact at the correct occlusal vertical dimension (OVD) for that individual.

Centric relation contact position (CRCP) – the occlusion of opposing teeth when the mandible is in centric relation; this may or may not coincide with the MICP (GTP 2017). This may involve one pair of teeth or several pairs or may coincide with all the teeth meeting. When the teeth touch then they slide from that position into MICP. According to Posselt (1952), 90% of the population have a discrepancy between both positions.

Other important terms are given in the table below and will be defined throughout the book and in the Glossary.

Term	Other names in the literature	Terms we will use in the book
Centric occlusion	Maximal intercuspal position, intercuspal position	Centric occlusion (CO)/intercuspal position (ICP)/maximal intercuspal position (MICP)
Centric relation	Terminal hinge axis or retruded axis position	Centric relation (CR)
Centric relation contact position (CRCP)	Retruded contact position, centric occlusion	Centric relation contact position (CRCP)
Maximal intercuspal position	Centric occlusion, intercuspal position, habitual occlusion, bite of convenience	Centric occlusion (CO)/intercuspal position (ICP)
Occlusal vertical dimension (OVD)	Vertical dimension of occlusion (VDO), dimension of vertical occlusion (DVO)	Occlusal vertical dimension (OVD)
Rest vertical dimension (RVD)	Rest position, physiological rest position, vertical dimension of rest	Rest vertical dimension (RVD)
Freeway space	Interocclusal distance	Interocclusal distance
Bennett angle	Progressive side shift	Bennett angle
Bennett shift (movement)	Immediate side shift	Bennett shift (movement)
Working side movement	Laterotrusive, laterotrusion	Working side movement
Non-working side movement	Mediotrusive, Mediotrusion	Non-working side movement

References

(2017). The Glossary of Prosthodontic Terms: ninth edition. *J. Prosthet. Dent.* 117: e1–e105.

Jiménez-Silva, A., Tobar-Reyes, J., Vivanco-Coke, S. et al. (2017). Centric relation–intercuspal position discrepancy and its relationship with temporomandibular disorders. A systematic review. *Acta Odontol. Scand.* 75 (7): 463–474.

McNamara, J.A., Seligman, D.A., and Okeson, J.P. (1995). Occlusion, orthodontic treatment, and temporomandibular disorders: a review. *J. Orofac. Pain* 9: 73–90.

Posselt, U. (1952). Studies in the mobility of the human mandible. *Acta Odontol. Scand.* 10 (Suppl 10): 19–160.

Shildkraut, M., Wood, D.P., and Hunter, W.S. (1994). The CR-CO discrepancy and its effect on cephalometric measurements. *Angle Orthod.* 64: 333–342.

Weffort, S.Y.K. and de Fantini, S.M. (2010). Condylar displacement between centric relation and maximum intercuspation in symptomatic and asymptomatic individuals. *Angle Orthod.* 80: 835–842.

2

Neuroanatomy – Why is It Important?

Introduction

What is the role of the teeth? An important question which underpins our clinical dentistry because we are routinely involved in possibly changing it if we don't follow a careful process.

The roles of the teeth can be thought of as follows.

- Mastication.
- Swallowing.
- Speech/phonetics.

This is a simplified view because the impact of teeth is far greater for both the individual but also when interacting with the wider community.

- Aesthetics – emotional and psychosocial perspective; this is specific to the individual and also has an impact on their self-esteem.
- Psychophysical – the ability to appreciate the food via texture, volume and taste.
- Occlusal stability and jaw support – maintain the elements that maximise function.
- Cognition – decreased mastication is a risk factor for dementia.
- Mortality – Osterberg et al. 2008 in numerous studies demonstrate the statistically significant correlation between the number of teeth remaining and mortality, with the data suggesting a 4% decrease in mortality for each remaining tooth above 20 occluding pairs. I am not suggesting that we tell our patients they will live longer if we provide more teeth but the link between quality of life and having fixed teeth is certain.

So how do we avoid altering this system in an uncontrollable manner? We use protocols and processes. The acronym for the process is STOP! STOP picking up that drill before you assess the occlusion. A preassessment of the occlusion is crucial to ensure we have not potentially affected the role or performance of the teeth. Therefore, we use our senses to reassess the occlusion. This is essential in both conformative and reorganised occlusion.

S – Survey – visual assessment using coloured paper to analyse contacts.

T – Touch – fremitus.

O – Observe and listen.

P – Patient feedback.

The goals of occlusion are as follow.

- To provide equal contacts on as many teeth as possible when the patient swallows – centric occlusion position. This will aid muscle health.
- To provide incisal guidance (protrusive guidance) on the anterior teeth. This will aid temporomandibular joint health.
- To provide group function when chewing using cuspal inclines.
- To avoid introducing new contacts (unless in a controlled manner) which may strain the adaptive capacity of the patient.
- To biomechanically distribute the forces so as not to cause failure of the restoration or other teeth.

Neuroanatomy

The aim of this chapter is to provide a clear understanding of the complex neural framework involved in mastication, swallowing and speech. The key objective is the information the brain requires to understand the position of the jaw in space and it acquires this information from the teeth, temporomandibular joint (TMJ), muscles and soft tissues.

An understanding of the neural framework involved in dental occlusion is essential in determining the protocols within clinical dentistry. The neural framework comprises the central nervous system (CNS) (spinal cord and brain) and the peripheral nervous system (connects the rest of the body to the spinal cord and brain). This is a feedback and feedforward system made up of sensory fibres (registering pain, pressure and temperature) and motor fibres (providing a function such as muscle contraction).

Anatomically, another structure which is important in our understanding of the masticatory system is the brainstem, which is the posterior part of the brain continuous with the spinal cord which is composed of three regions:

- medulla oblongata
- pons
- mesencephalic area.

Why do I need to know this, I hear you ask? Well, within this area are the central pattern generators (CPGs) generally defined as a network of neurons (nerve cells) capable of enabling the production of central commands, specifically controlling stereotyped rhythmic motor behaviours such as mastication, deglutition, respiration and locomotion, among others. There is increasing evidence suggesting that some of these CPGs are interconnected for co-ordinated control.

In this chapter we will only be dealing with mastication and deglutition. For further reading, the article by Steuer and Guertin (2019) goes into greater detail. Kandel (2012) stated that the brainstem is an important element of motor and sensory function and plays a key role in the control of mastication and deglutition.

Mastication

This process needs sensory input for the CPGs and this comes from the periodontal mechanoreceptors (PDMRs), muscles, bones, TMJ and soft tissues. Other inputs from the higher centres of the brain can also affect the basic output from the CPG. The output through the motor fibres is relayed in the descending pathway to the muscles to apply forces to break food down. This process is constant and if we bite on something hard which we are not expecting then a reflex arc is created, i.e. jaw opening reflex (Figure 2.1).

Most foods that we are used to eating do not require attention, but when we try a new food the higher order brain centres are involved as we investigate (attention is required) this new substance in regard to texture and taste and a decision is made whether we will eat this again. This is feedforward learning. Age and types of food can also modulate mastication activity as stated by Peyron et al. (2004).

What is the Goal of Mastication?

The goal of mastication is to increase the surface area of food to enhance enzymatic action. Therefore, our teeth (incisors, canines, premolars and molars) are designed to crush and shear the food.

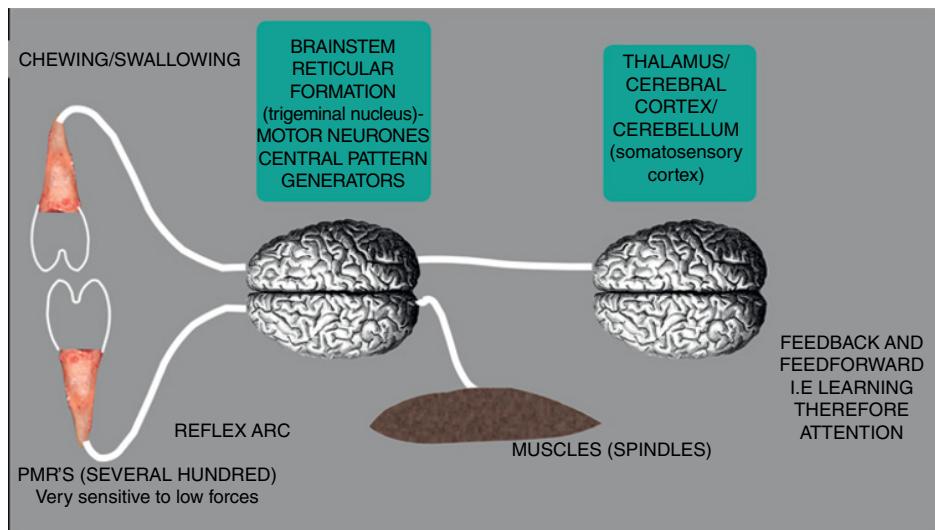


Figure 2.1 Signal pathways. PDMR (afferent neurons) are triggered (sensory and motor) and the impulse is detected in the trigeminal ganglion and the trigeminal mesencephalic nucleus. The information is then relayed at the brainstem and finally projected to the primary somatosensory cortex. The output from the cortex seems to be important for initiating and co-ordinating masticatory movement and adapting to the hardness of the bolus. *Source:* Modified from Morquette et al. (2012).

- Incisors – designed to grab and cut through food (to incise).
- Canines – designed to grab and tear through food (cornerstone of the arch).
- Premolars – designed to crush food and seen as transitional due to having anatomical features of both canines and molars (the equilibrium point of the arch).
- Molars – designed for grinding food.

The muscles involved in mastication are responsible for moving the jaws in a manner that brings the teeth into contact rhythmically. When the muscles are inflamed this process can be painful and uncomfortable. Certain activities can cause this such as:

- hypernormal function – habits such as nail biting, chewing gum
- parafunction – clenching (static) and bruxism (dynamic).

Muscles involved in jaw opening (smaller muscle mass group).

- Lateral pterygoid.
- Suprahyoid muscles – anterior digastric, mylohyoid, geniohyoid.

Muscles involved in jaw closing (larger muscle mass group underlying where the greater activity is).

- Temporalis.
- Masseter.
- Medial pterygoid

The innervation for these muscles is via the trigeminal nerve (V) but other cranial nerves such as the facial (VII), glossopharyngeal (IX) and hypoglossal (XII) are also involved in the whole process of mastication and swallowing, which comprises more than 30 nerves and muscles (Matsuo and Palmer 2008). Some of these muscles are also involved in respiration and are considered accessory respiratory muscles as discussed by Van Lunteren and Dick (1997).

The pattern of mastication is made up of three successive cycles as described by Lund (1991).

- 1) The *preparatory phase* – also called the gathering stage, when the incisors bring the food into the mouth and shift it deeper onto the posterior teeth.
- 2) The *reduction phase* – breakdown of food in a rhythm called the chewing cycle; as the food gets smaller, the teeth start to contact, letting us know that the food is ready for swallowing
- 3) The *preswallowing phase* – the bolus is prepared for swallowing, the tongue places the food posteriorly and the swallowing reflex is initiated.

The evidence also supports sensory feedback controls for a large part of the masticatory process. Soft foods mean a short masticatory sequence and tough foods provoke a longer sequence, as discussed by Plesh (1986).

Let's look at the sensory feedback system in more detail (Figure 2.2).

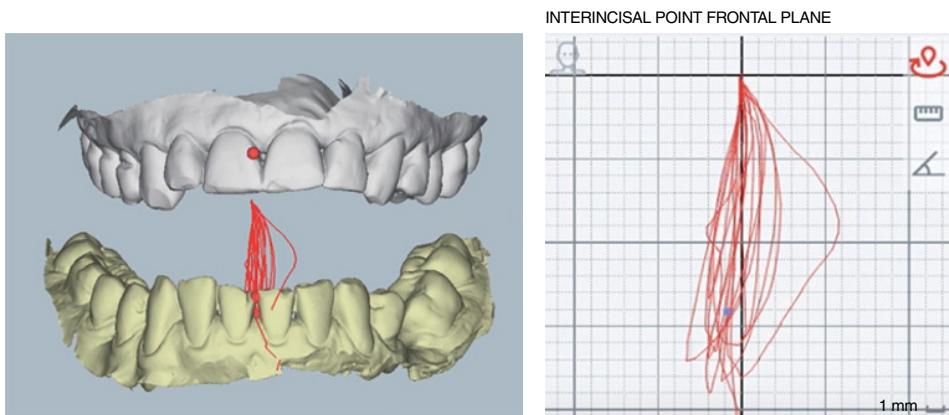


Figure 2.2 Chewing cycle data collected using MODJAW (for further details on MODJAW see Chapter 12).

Sensory and Motor Feedbacks

PDMRs

Situated close to the collagen fibres and in between like a sandwich within the periodontal ligament and described as Ruffini-like by Byers (1985) and Lambrechts (1992) in humans. The main periodontal Ruffini nerve endings have been classified as type 1 and 2. Type 1 shows lamellar terminal Schwann cells and expanded axon terminals with axonal spines which penetrate surrounding tissue; type 2 is characterised by lesser branched Ruffini endings with fewer axonal spines, less basal lamina and fewer Schwann cells. Both of these receptor types are present in the periodontal ligament (Maeda et al. 1999).

These are crucial for force interpretation and control of mastication and therefore it would be assumed that the different teeth (incisors–molars) would have differing sensitivity thresholds and this has been shown to be correct by Johnsen et al. (2007). This is called the interocclusal tactility threshold (ITT) as discussed by Herren (1988) and this study uses foils of varying thickness between healthy teeth. The smallest ITT recorded is between 8 and 60 μm but during chewing the threshold increases by a factor of 5 (range 2.5–8 \times) and the occlusal perception is reduced due to descending inhibition (sensory gating), meaning there is a filtering out of irrelevant information which allows for enhanced detection of unexpected stimuli. There are also interindividual variations which are ascribed to differing attentional degrees in the higher brain centres and this will be linked to adaptability and neuroplasticity (capability to change and adapt to new demands).

The direction of force also shows that the PDMRs respond more when the forces are axial, i.e. in the direction in which they function best – ‘Directional bias may reflect functional adaptation’ (Sato 1988). When force is applied, the collagen fibrils are compressed which fires the mechanoreceptors. The use of the split and hold tests by Trulsson and Johansson (1996) also determined the amount of force required through a positive feedback loop, meaning the harder the food, the more force is applied through the initial feedback from the mechanoreceptors. A recent systematic review by Piancino et al. (2017) summarises studies that looked at this in greater detail.