Making Occlusion Work: I. Terminology, Occlusal Assessment and Recording

A.J. McCulloch

Abstract: This is the first paper in a two-part series reviewing some of the relevant theoretical aspects of occlusion and describing its application in clinical practice. This article discusses terminology, clinical examination of the occlusion, articulators and interocclusal records.

Clinical Relevance: Occlusion is of fundamental importance in restorative dentistry, as all restorations placed in the mouth can have a profound effect on it. From intracoronal direct placement restorations to complex crown and bridgework, the restoration must be planned to conform to an occlusal pattern, and not disrupt it unless for very specific reasons.

The study of occlusion involves not only the static relationship of teeth but also their functional interrelationship and all the components of the masticatory system. The muscles of mastication, the neural feedback pathways, the temporomandibular joints and the shape of the occluding surfaces of the teeth influence the positions and movements of the mandible. The way in which teeth meet and move over each other must be understood so that any restoration placed in a mouth will be part of a harmoniously functioning occlusion.

The occlusion achieved during normal functional mandibular movements, such as swallowing and chewing, occurs within a relatively small space called the envelope of motion. Abnormal movements are dysfunctional, caused by derangement of the articular disc and muscle hypertrophy. Parafunctional activity is usually habitual, the patient often being unaware of the movement, and includes bruxism, clenching, jaw posturing, lip and pencil biting. These activities can create excessive forces between teeth or produce normal forces at an abnormal frequency, producing a risk of:

- fractured cusps or restorations;
- increased tooth mobility;
- muscle fatigue; and
- toothwear.

A harmoniously functioning occlusion allows for smooth uninterrupted movements over the area of tooth contact. Some occlusions may not permit such free movements, yet the patient does not exhibit the problems described; his/her neuromuscular system has adapted to the disharmony. However, if a restoration is placed which changes the occlusion, the adaptive capacity of the system may be exceeded, leading to the signs and symptoms listed above.

Every restoration, whether a simple amalgam filling or complex crown and bridgework, that involves the occlusal surface will affect the occlusion. Therefore restorations should be planned so that they do not cause effects that exceed the adaptive tolerance.

TERMINOLOGY

Posselt described the extreme or border movements of the mandible as an envelope of motion. They represent the movement of the tip of the lower incisor when viewed in the sagittal or frontal plane (Figure 1).

The mandible initially opens with a hinge movement about a horizontal axis known as the retruded axis or terminal hinge axis (THA), with the condyles in the retruded position (RP) (centric relation). This is described as the most superior position of the condyles in their fossae. The RP is clinically reproducible in both dentate and edentulous patients.

- When the mandible rotates around this axis the first tooth contact occurs – the retruded contact position (RCP).
- The mandible then slides forwards bringing the teeth into maximum intercuspation – the intercuspal position (ICP) (centric occlusion).

The discrepancy between RCP and ICP has both a vertical and horizontal component and may be up to 1 mm. However, patients with this slide usually close straight into ICP from the rest...
position – the habitual path of closure. Contact between opposing teeth can occur in the area of this discrepancy during swallowing, mastication and parafunctional activity. When teeth are in the intercuspal position the occlusal vertical dimension (OVD) is defined as a measurement of face height. When not in contact, teeth are held apart in the rest position by the muscles of mastication acting on the mandible creating a freeway space or interocclusal distance of 2–4 mm. In practice, this position is variable, being affected by posture and muscle activity.

When mandibular teeth move from ICP to maximum protrusion their path is determined by the articulating surfaces of the anterior teeth, creating anterior guidance. This does not exist in anterior open bites or edge-to-edge incisor relationships, where during protrusion the guidance is obtained from the occlusal surfaces of the posterior teeth. The angle and length of the movement is determined by the incisor relationship. In Class II division II occlusions the movement is almost all vertical as the lower incisors are locked palatal to the upper incisors and cannot slide forward. Their incisal guidance produces a different tracing in Posselt’s diagram (Figure 1).

ICP is maintained and occlusal forces directed axially by two types of interocclusal contact: the palatal cusps of the maxillary teeth and buccal cusps of the mandibular teeth (called supporting cusps) contact the inclined planes of the opposing dentition or the cusp tips contact the opposing fossae. The maxillary buccal and mandibular lingual cusps are therefore the non-supporting cusps. These contacts are reversed in crossbite so it is important that each occlusion is assessed individually. During lateral excursions, the side to which the mandible moves is the working side and the opposite side the non-working side. On the working side, when only the canines are in contact during lateral excursions, the occlusion is canine guided; if two or more pairs of teeth contact in this movement the occlusion is in group function. This may involve both anterior and posterior teeth.

On opening from RCP the mandible rotates around the THA in an arc of a circle (point Y on Figure 1). This creates an incisal separation of about 2.5 cm. On further opening the condyles translate or slide downwards and forwards along the articular eminencies of the glenoid fossae to a point of maximum opening (Figure 1; O). During lateral movements, the working side or rotating condyle may rotate and move laterally as well as upwards, downwards or backwards. The lateral component is termed the Bennett movement. The first part is called immediate sideshift and is measured on average at 0.5 mm. The progressive sideshift describes a more gradual lateral
movement. The non-working side or orbiting condyle moves downwards, forwards and inwards, creating the Bennett angle (Figure 1).

The free-sliding movement of the mandible can be disturbed by an occlusal interference occurring between opposing teeth. The interference may arise as a result of tooth movement, over-eruption or occlusal wear in the unrestored dentition or of poorly contoured restorations. To maintain occlusal stability there must be adequate occlusal contact to prevent such interferences. This stability can be maintained by assuring occlusal contacts are not on inclined planes but ideally in a cusps-to-fossa or cusps-to-marginal ridge position.

ASSESSMENT OF THE OCCLUSION

The diagnostic process begins with careful history taking and clinical examination. Signs and symptoms of clicking or locking of the temporomandibular joints, muscle spasm, excessive or uneven occlusal wear and pain on chewing must be recorded. Further investigations including radiographs, vitality tests and articulated study casts will provide additional information.

The examination should include:

- Mandibular movement – painful, deviated, abnormal or restricted.
- Intra-oral features:
  1. Intercuspal position, retracted contact position, lateral and anterior guidance.
  2. Presence, angle and smoothness of any slide from RCP to ICP.
  3. Location and extent of occlusal faceting.
  4. Ease of movement between mandibular positions as in 1.
  5. Extent of posterior support.
  6. Over-erupted, tilted or mobile teeth.

DETECTING OCCLUSAL CONTACTS

Articulating paper is used to mark or indicate the position of occlusal contacts. Thin articulating paper such as GHM occlusion foil (Hanel-GMH-Dental GMBH, Nurtingen, Germany), which is 19 microns thick, marks true contact points; thicker paper (70–200 microns) can produce inaccurate and often larger points. However, none of these papers readily registers contact on glazed porcelain or polished gold surfaces.

To show occlusal contacts the teeth must be dry. Articulating paper, held in Miller’s forceps (Figure 2), is placed between the teeth and the mandible guided into whichever position is being assessed to record the points of tooth contact. Articulated study casts, mounted on a semi-adjustable articulator using a facebow record, provide more detailed information that cannot be readily assessed in the mouth. The casts must be articulated in RP so any slide from this position to ICP is detectable. The interocclusal records must also include lateral excursions and protrusion so both the horizontal and vertical condylar guidance and incisal guidance can be programmed into the articulator.

Retruded Contact Position

The RCP is located using the following technique:

- The patient is placed in the supine position with the chin pointed upwards.
- The operator sits behind the patient and places his or her thumbs on the patient’s chin and fingers on the lower border of the mandible (Figure 3).
- By gentle manipulation the mandible can be moved into the retracted position.
- The patient is instructed to raise his/her hand on whichever side contact is first felt. This will verify the clinical impression gained by the dentist.

The process is repeated using articulating paper to verify the contacts. In those patients with a tense musculature, who cannot relax readily,
difficulty will be experienced in recording the maxillomandibular relationship at the position in which the occlusal interference occurs. This should be suspected when the patient resists attempts to manipulate the mandible by forcibly holding the jaw in one position and is unable to make easy voluntary movements. It is often necessary to have several attempts to educate a patient to relax. A cotton wool roll placed between the patient’s front teeth for a few minutes (Figure 4) is a useful technique to help at the initial assessment.

However, to identify the occlusal interference in RCP accurately, the proprioceptive feedback mechanism must be de-programmed from its habitual path of closure so the casts can be mounted on the retruded axis. An anterior acrylic jig or full maxillary coverage acrylic splint may be used. Although each is designed differently, the aim is the same. The anterior jig can also usefully be incorporated into an interocclusal record. In principle the jig, which covers the upper central incisors, is shaped to have contact with the lower central incisors in RP and create a posterior separation of 2 mm. The acrylic Michigan splint, which is also constructed in RP, uses complete occlusal coverage of the upper teeth. In acting as a diagnostic appliance it aims to achieve muscle relaxation and allow condylar repositioning so the retruded axis position can be located.

Discrepancy Between RCP and ICP
The mandible is manipulated into RCP and the patient instructed to slide his or her teeth together until they meet in ICP or in the position that feels correct to them. This is identified using articulating paper. Lateral excursions are then made to detect the nature of the guidance and finally protrusive movement is used to demonstrate the type of anterior guidance.

ARTICULATORS
Articulators (Figure 5) are mechanical devices that hold casts to allow the examination of occlusal relations and the fabrication of restorations in the laboratory. Articulators may be classified into the following groups:

- simple hinge;
- average value;
- semi-adjustable – arcon or non-arcon;
- fully adjustable.

Simple Hinge
The simple hinge articulator allows rotational movement only, around a horizontal axis that bears little relationship to the patient’s terminal hinge axis because a facebow transfer is not used. This is adequate when other unprepared teeth on the working cast maintain ICP. Restorations can be made only in ICP and intra-oral adjustment may be necessary in lateral and protrusive movements unless there is steep anterior guidance leading to immediate posterior discclusion.

Average Value
Average value articulators allow a limited range of protrusive and lateral movements based, as the name suggests, on the average patient through a fixed condylar guidance mechanism.

Semi-adjustable
Semi-adjustable articulators can be set to simulate mandibular movements well
enough for many clinical situations. Their condylar guidance mechanisms are set from lateral and protrusive records and the maxillary cast is related to the hinge axis of the articulator using a facebow transfer. There are two types of semi-adjustable articulator:

- The arcon (articulator-condyle) type, for example the Denar Mark II (Denar Corporation, Anaheim CA, USA), has an adjustable condylar fossa mechanism that sits on a fixed condylar sphere, attached to the lower member, on which it is free to move. The upper member is detachable from the rest of the articulator. It maintains the fixed relationship of the maxillary occlusal plane to the condylar guidance angle.

- Most non-arcon types, such as Dentatus (Pro-Care Europe Ltd, Bradford, UK), have a moving condylar sphere set in an adjustable condylar track, which is not removable.

The advantage of the arcon type is that it more closely represents the anatomical relation between the condyle and glenoid fossa; as the upper member is removable this type is of great help in many laboratory-based procedures.

**Fully Adjustable**

Fully adjustable instruments are of the arcon design and are very sophisticated. They are set using either interocclusal records or a pantographic tracing and a record of the true terminal hinge axis to duplicate mandibular movement with a high degree of accuracy.

Articulators are set using interocclusal records. Semi-adjustable machines use the lateral and protrusive records to set the condylar elements to replicate some of the posterior determinants of the occlusion (condylar guidance, the Bennett angle and movement). RCP records allow the casts to be mounted so that an existing slide between RCP and ICP can be duplicated and potential occlusal interferences from new restorations avoided.

Readers should refer to more detailed texts for in-depth descriptions of each type of articulator.

**THE FACEBOW TRANSFER**

The facebow (Figure 6) records the relationship between the patient’s terminal hinge axis, whether it is true (accurate) or arbitrary (imprecise) and the maxillary teeth are enabling this to be transferred to the articulator, so relating the hinge axis of the articulator to the maxillary cast. Casts are articulated in RCP then brought together

---

<table>
<thead>
<tr>
<th>Type of Restoration</th>
<th>Interocclusal Record</th>
<th>Articulator</th>
<th>Potential Interferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single anterior unit (C)</td>
<td>None, ICP</td>
<td>Not usually necessary/simple hinge</td>
<td>RCP, protrusive</td>
</tr>
<tr>
<td>Single posterior unit (C)</td>
<td>None or ICP</td>
<td>Not usually necessary/simple hinge</td>
<td>RCP, protrusive</td>
</tr>
<tr>
<td>Last standing molar (C)</td>
<td>ICP</td>
<td>Simple hinge</td>
<td>RCP, lateral, protrusive</td>
</tr>
<tr>
<td>Multiple anterior units (C)</td>
<td>ICP, protrusive</td>
<td>Semi-adjustable plus customized incisal guidance</td>
<td>Minimal</td>
</tr>
<tr>
<td>Multiple posterior units in one arc (RO)</td>
<td>(a) ICP or (b) ICP, lateral/protrusive</td>
<td>Average value or Semi-adjustable plus facebow transfer</td>
<td>RCP, lateral, protrusive</td>
</tr>
<tr>
<td>Multiple units in both arches (RO)</td>
<td>RCP, lateral/protrusive</td>
<td>Semi-adjustable plus facebow transfer or fully adjustable</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

*A semi-adjustable articulator is suitable for most patients. C: conformative approach; RO: reorganized approach.

**Table 1. Indication for occlusal records and type of articulator.**

Figure 7. (a) Softened interocclusal wax record. (b) Buccal cusps visible on record. (c) Record relined with temporary cement. (d) Rigid, stable, accurate record.
to examine occlusal contacts. Where a patient’s occlusal vertical dimension is to be altered using restorations, a semi-adjustable articulator with a facebow transfer must be used (Table 1).

The arbitrary hinge axis is adequate for most clinical procedures. It is located 13 mm from the tip of the tragus of the ear on a line joining this point to the outer canthus of the eye. This point is marked on the face and the condylar rod of the facebow placed over it. Some facebows use the ear as the point of reference; this is more accurate than other average points marked on the face and simplifies the clinical recording process.

The third reference point relates the maxillary cast to the Frankfort plane. Some facebows use the infra-orbital notch and others have a plastic ‘nose piece’ that rests on the bridge of the nose during the recording. The occlusal plane in its sagittal relationship to the horizontal is then identified.

INTEROCCLUSAL RECORDS
These records relate the mandibular and maxillary diagnostic and working casts in RCP, ICP, OVD, protrusion and lateral excursions. The record should be made at the correct OVD in the absence of any temporomandibular joint or muscle dysfunction, using the appropriate mandibular guidance and an accurate and dimensionally stable material. To ensure the accuracy of the mounting, it must be checked with shimstock such that the intra-oral contacts and those on the casts coincide.

The ideal recording material:

- is initially soft and fluid;
- does not displace the soft tissue or teeth;
- does not interfere with mandibular movements; and
- is stable and accurate once set.

Extra hard base plate wax is suitable. Other materials include zinc oxide and eugenol paste, elastomers and impression plaster.

A wax record is made of two thicknesses of base-plate wax that will not distort during removal from the mouth. The record should be about 2 mm thick to ensure that purely rotational movement of the condyle occurs (rather than translocation) when RCP or ICP is recorded. The wax record may need to be thicker for protrusive excursions as there will be greater separation of the posterior teeth. The protrusive condylar path is curved, following the anatomy of the glenoid fossa, and on some arcon articulators this can be replicated with customized acrylic tables or nylon inserts. The protrusive record is taken with the teeth in an edge-to-edge position. The protrusive record needs to record this degree of movement but no further forward – except in edge-to-edge relationships when the mandible should be protruded no further than 5–6 mm.

Single Posterior Tooth or Quadrant Preparations using the Conformative Approach
When a single standing molar tooth has been prepared and is the only vertical stop on one side of the mouth the following technique is suggested to record the occlusal relationship (it can also be used when whole quadrants are prepared). An alternative technique is discussed in the second article. The record may be made covering only the prepared teeth with the unprepared teeth in occlusion.

- Extra hard base plate wax is thoroughly softened in a water bath.
- Two thicknesses are shaped, placed over the prepared tooth/teeth and the mandible guided into RCP or ICP.
- Once cooled the record is removed from the mouth and inspected.

It can be further improved by using zinc oxide eugenol paste or temporary cement as a relining agent (Figure 7). Where a Lucia jig has been used to help identify RCP, this can be incorporated in the wax record, the anterior part of the record being cut away to accommodate it.

All Posterior Teeth Prepared in One Arch using the Reorganized Approach
When all the posterior teeth in one arch have been prepared the anterior teeth and condyle in its THA maintain the occlusal vertical dimension. In making the interocclusal record the anterior teeth must contact without interference from the record.

Softened baseplate wax is formed to cross the arch, providing a rigid base. A horseshoe-shaped piece of wax readily distorts during removal from the mouth and should not be used. Once hard, the record is removed and examined and improved as above.

Where there are insufficient teeth to support a stable record wax, occlusal rims on a stable wax or acrylic base can be used (Figure 8). The jaw relationship and vertical dimension should be determined before tooth preparation, ensuring that these parameters are maintained after the occlusal stops have been reduced. Having lost its reference points the mandible can become repositioned, resulting in a change in
RCP and the vertical dimension – so reducing the space between opposing teeth and producing problems in identifying the correct positions for the restorations.

THEORIES FOR ACHIEVING OPTIMAL OCCLUSAL CONTACT

There are many different occlusal philosophies and treatment concepts that aim to deliver optimum occlusal contact and hence health in both the natural and restored dentitions. Diverse opinions have led to much controversy as to which concept is the best to use. Two main concepts have existed in the past. One is the prosthetic concept of a balanced occlusion with bilateral tooth contacts in lateral and protrusive excursions to ensure functional stability. The other theory is orthodontically oriented to achieve particular static cusp-fossa relationships. These two theories of ideal standards and that of dynamic occlusal relationships are outlined below.

Gnathology

- Point centric – obtainable and reproducible.
- Tripodized occlusal contacts.
- Canine disclusion.
- Importance of posterior determinants.
- Anterior teeth concave palatally.
- Posterior teeth form a parabolic curve.
- Use of fully adjustable articulator.
- All restorations done together.

Pankey–Mann–Schulyer (PMS)\(^{10}\)

- Long centric (or freedom in centric).
- Anterior guidance all important.
- Group function then canine rise after 1 mm of movement.
- Posterior teeth flatter.
- Lower posteriors restored first then functionally generated path technique.
- Anterior teeth ledged to provide occlusal stops.

Devotees of these philosophies adhere strictly to them but in the past few decades a third concept – the ‘dynamic individual occlusion’ – has emerged. The criteria for diagnosing occlusal problems and the indications for treatment are based on an assessment of the health and function of each individual’s masticatory system. The implication is that individuals do not necessarily fit into a prescribed occlusal concept but that each occlusion should be considered separately and treatment needs to be tailored to individual requirements.

REFERENCES


BOOK REVIEW


Designing a book which will appeal to general dental practitioners is not an easy task. GDPs are a heterogeneous group, and it is difficult to identify correctly what these different individuals want or require from a text. However, this book will, in my opinion, succeed by its choice of content and by achieving a good balance between the practical and the scientific.

Although this is a short volume, it is primarily concise and gets across a lot of information within the space available. In its eight chapters, two are devoted to basic concepts of pathogenesis and diagnosis of pulpal conditions, but the science is clearly related to subsequent management. The next five chapters cover the traditional phases of endodontic therapy. Well placed emphasis is put on the importance of access, and diagrams of ideal access cavities for all teeth are included. Throughout the text there are practical tips and problem-solving ideas, for example accessing calcified teeth and rubber dam placement. Good use is made of photographs, and the many line drawings complement the text. A shortlist of additional sources of information completes each chapter.

Many practitioners will be interested in, but also perhaps confused by, the recent range of rotary preparation devices and obturation techniques being marketed. They will therefore value the description of traditional hand-preparation techniques, which is followed by a concise and clear section on newer modalities, including how they are best used. A final section on realistic assessment of success and failure rounds off this excellent book.

This is not an academic treatise nor is it a basic manual. It contains much more than just the essentials and should be well received by all general practitioners who wish to improve or maintain their endodontic treatment abilities.

Dominic Stewardson
The University of Birmingham School of Dentistry