In part three, Dr Paul Tipton describes the diagnostic work required for the full mouth reconstruction at an increased vertical dimension.

**Treatment planning**

All comprehensive treatment planning should begin with an occlusal aesthetic evaluation. Evaluation of the face is essential in determining the ideal aesthetic orientation of the teeth from both a horizontal and vertical perspective. The horizontal reference planes will help the clinician align the occlusal plane and the soft tissue levels along with other related aesthetic determinants. The horizontal reference planes should be evaluated from two perspectives: the frontal and the sagittal. The frontal perspective is assessed by having the patient look out into the horizon and choosing the ideally leveled plane. The most commonly used horizontal reference planes include inter-pupillary line and inter-commissural line (Figure 1).

Intra-oral photographs are also key at this stage (Figures 2-4). The following steps are essential to fulfilling the correct diagnosis.

**Step 1: Mounted study casts**

This is achieved by taking accurate alginate impressions of upper and lower jaws in rim-lock trays, facebow recording and jaw registration around RAP. The technician can now mount the study casts in a semi-adjustable articulator (Figures 5-8).

**Step 2: Vertical dimension**

The first treatment planning decision is what vertical dimension to work at (part five). This can be established by the use of a wax squash bite placed into the patient’s mouth. As the patient is manipulated into RAP the lower teeth indent the wax bite. This can be removed, chilled in iced water and replaced as the patient and clinician now assess profile and facial aesthetics. In this way changes in vertical dimension can be transferred early to the technician on the articulated casts and the initial new occlusal plane assessed via an elastic band (Figures 7-8). Once mounted, the degree of over-eruption of either arch can be assessed (Figures 9-10) and casts adjusted (Figures 11-12).

**Step 3: Lower incisal edge position**

The incisal edge position, incisal plane and occlusal plane are the three most important aesthetic determinants in the development of the treatment plan. These determinants enable the clinician to transfer information throughout the treatment, and are related in specific ways to other aesthetic criteria. The first step in determining the position of the teeth is evaluation of the lower incisal edge at rest (Figure 13). Tooth exposure is...
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considered to be in the zone 1 to zone 4 range dependent on age. To achieve the correct position the edges of the lower anterior teeth need to be shortened or lengthened by either removing stone or adding wax. For example, if crown lengthening is indicated on teeth that were previously ideally proportioned, the incisal edge length can be reduced. Establishing the correct amount of lower tooth exposure dependent upon the age of the patient at rest should be the goal. Once the final lower incisal edge position is determined, the lower occlusal plane is evaluated.

Step 4: Curve of Spee

For this the PMS method is used to establish the anatomically average curves of Spee and Monson, of the radius of a 4° circle. This is done using a Boyles plane analyser (Figure 14). For this three reference points are required. One has already been established and that is the position of the lower incisal edge position as per the aesthetic requirements of the patient dependent upon age. The amount of wax added to the lower incisors or amount of stone removed from the lower incisors on the mounted study casts is established by using the lip as the reference plane and calculating where the lower incisal edges are and where they should be. This new level is transferred to the technician so that his starting point for the wax-up is the two lower incisal edges. The two posterior reference points are the retro-molar pads (Figure 15), which have been shown not to change during life/tooth loss etc. There is a certain amount of flexibility when establishing these two reference points as being half-way and two thirds of the way up the retro-molar pads. The lower occlusal plane is established by the Boyles plane analyser resting on the waxed-up or adjusted lower incisors and the two posterior reference points on the retro-molar pads. Any over-erupted teeth are ground down and any teeth not touching are waxed-up to the analyser. This creates the ideal lower occlusal plane (Figures 16-18). The lower incisal plane should be levied to the chosen horizontal reference plane (the inter-commissural line, inter-papillary line etc., and evaluated from the frontal perspective while the patient is smiling. The next step is to evaluate the occlusal plane from a sagittal view of the patient’s smile.

Step 5: Upper incisal edge position

Next, the upper incisal edge position should be established. This is done by aesthetics and phonetics, especially the ‘F’ and ‘V’ sounds to establish the labio-lingual position. Aesthetically, the incisal edge position is evaluated in relationship to the upper lip at rest. Age is again used as a guide and it is common that the range of incisal edge show may be between 3mm and 5mm. The horizontal anterior planes, inter-papillary line and inter-commissural lines are again used to establish the correct positions. The midline position of the upper incisors can be taken from several anatomical landmarks such as the facial midline, nasal midline, lip midline etc. Studies suggest the closest anatomical landmark is the most important – i.e. the midline of the upper lip. Technicians and clinicians should also realise the extent to which they can change midlines without reverting to root canal therapy – approximately 1.5mm to 2.5mm depending upon the size of the teeth.

Step 6: Establishing anterior guidance

Any space between the lower incisal edges and the palatal aspects of the upper anterior teeth is now closed by waxing the palatal aspects of the upper palatal aspect down to contact the lower incisal edges to gain an incisal and canine stop in the intercuspal positions (Figure 19). Adequate anterior guidance is a complex function directly related to the form of the teeth and thus to the vertical and horizontal overlap of the incisors and canines. Anterior guidance is influenced by the proprioception of those teeth, which provides feedback to the masticatory muscles and influences the entire masticatory system. Unlike the posterior determinants, such as the slope of the articular eminence, the vertical and horizontal overlap of the anterior teeth are – to variable degrees – amenable to modification. However, any modifications of the anterior teeth must satisfy not only the aesthetics and phonetics, but also the overall function. If the disclusial angle is too steep, temporomandibular joint or muscular discomfort may result.

Step 7: Maxillary occlusal surfaces

Once the mandibular teeth are ideal in shape and form, wax is added to the maxillary posterior occlusal surfaces to occlude against the mandibular occlusal surfaces in the correct relationship. Correct occlusal shape and form and ridge and groove direction, depth of fossae and height of cusps are now established at the set vertical dimension dependent upon the choice of articulator, facebow and articulator setting devise, check bite, cadrax, pantograph (Figures 20-22).

Step 8: Refine the occlusion

The occlusal surfaces can be corrected to perfect the occlusal relationship and to idealise the aesthetic

Figure 13: Lips at rest
Figure 14: Boyles plane analyser
Figure 15: Lower study cast showing retro molar pad
Figure 16: Lower arch waxed up to correct curve of Spee and Monson using the boyles plane analyser - right hand side
Figure 17: Front
Figure 18: Left hand side
Figure 19: Wax-up of upper model showing contour and shape of palatal aspects
Figure 20: Max-up completed – right hand side
Figure 22: Left hand side
Figure 21: Front
Figure 22: Left hand side
Figure 23: Final facial view
Figure 24: Final smile close up
Figure 25: Pre-restorative smile
Figure 26: Pre-restorative smile – close up of the smile
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† Containing 5% potassium nitrate and 1450 ppm fluoride as sodium fluoride.
‡ Containing 1450 ppm fluoride as MFP.

References:
contours by the further addition or subtraction of wax. The final contours of the central incisors should be determined first, followed by the lateral incisors and canines, since the symmetry of these teeth is as critical as the central incisors.

**Step 9: Restoration**

The final restorations can be seen in Figures 23 and 24. The step-by-step procedures in the restoration will be discussed during the next case study.

**Case study**

Mr. O was referred to me from Birmingham for a full mouth reconstruction (Figures 25-26). On examination there was marked amounts of wear present and loss of vertical dimension (Figures 27-28). Mounted study casts were taken and the vertical dimension – to which the final restorations were to be fabricated – assessed as per the previous discussion (Figures 29-30). The diagnostics and treatment planning protocols discussed in this paper were used to establish the ideal aesthetic and functional end result so that the diagnostic waxing, prep guides and prototypes were produced.

Reconstruction then followed along established guidelines of initially an occlusion splint to establish the correct RAP prior to starting tooth preparation procedures. All teeth were initially prototyped starting with upper and lower anterior teeth then one side followed by another side over a period of three visits during one week.

Once the prototypes had been in place for a period of time to establish the correct occlusion, function and aesthetics and the patient was comfortable, sections of prototypes were removed, definitive preps, impressions, occlusal records and facebow were taken and final restorations fabricated and fitted. Again, upper and lower anterior crowns were fabricated and fitted first to establish and copy (via a custom-made incisal guidance table) the established anterior guidance (Figures 31-33). This was followed by one side then another in the same way. The final result can be seen in Figures 34-36. Finally, a post-restorative splint was made for night-time use.

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