Recent advances in fixed appliance treatment in orthodontics are based on a combination of applied knowledge and the use of materials relating to that knowledge. For self-ligation, the applied knowledge consists of the generally transferable skills involved in diagnosis and treatment. The hardware consists of brackets, archwires, and bands, which are used for treatment with conventional fixed appliances. All of the approaches used in self-ligation are identical to those used for general treatment with conventional fixed appliances.

Fixed appliance treatment is easier when straight-wire techniques are used, and auxiliary elements are often useful. The basic principles, however, are the same for self-ligation as in conventional orthodontics—for example, bracket placement is of paramount importance for good finishing. Inadvertent errors in bracket placement can be compensated for either by repositioning the brackets or by using first-, second-, or third-order bends. Self-ligation does not confer any advantages in this respect.

Self-Ligating Brackets

Like ordinary fixed appliances, a self-ligating bracket consists of a bracket base and a body containing slots and tie-wings (**Fig. 2.1**). The difference between conventional and self-ligating brackets lies in the way in which the archwire is engaged in the slot. In self-ligation, the bracket itself contains a clip or other mechanism, which is used instead of either elastic or metal ligatures.

Just like conventional brackets, self-ligating brackets really only serve one function: they are the junction between the element generating the force (wire or auxiliary) and the tooth—so that they are simply a means to an end. The use of self-ligating brackets has given rise to a number of treatment philosophies, which are believed to offer significant advantages over ordinary ligation. However, it is important to remember that the tooth is not aware of how the force is being applied to it—whether it is by self-ligation or ordinary ligation.

A number of challenges that apply to traditional brackets also apply to self-ligating brackets: the fit of the bracket base to the tooth, the precision of the archwire slot, etc. There are few differences between self-ligation and ordinary ligation, as the method of production for the two systems is identical. Depending on how self-ligating brackets are manufactured, there may be a number of technical issues with the locking mechanism, which are described in greater detail in the section on “Rotation and Friction” below.

An ideal self-ligating bracket should have the following characteristics:

- Anatomically appropriate curvature of the bracket base including retention and undercut
- Marking of the vertical and horizontal axis
- An appropriately designed layout for good bracket positioning
- The bracket should be identifiable for each individual tooth (color coding or laser engraving)
- Hooks should be available for the application of elastics
- Precise slot dimensions (either 0.018 or 0.022)
- Robust self-ligating mechanism
- Twin tie-wings for engaging elastic chains or elastic modules
- Additional auxiliary slots

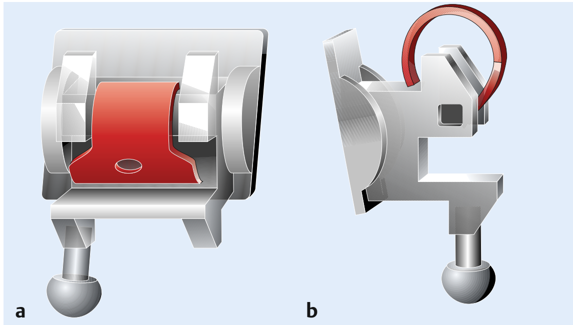

Fig. 2.1 a, b The general design of a self-ligating bracket.

Bracket Base

The bracket base connects the bracket to the tooth and therefore must have retentive elements such as mesh, undercuts, or other retentive features which allow for good band strength. The adhesive enters the undercuts and allows mechanical retention, which should be resistant to everyday masticatory forces on the one hand, but should still be capable of being debonded without damaging the enamel surface on the other.

Shape of the Base

An ideal base should follow the curvature of the respective tooth surface for a good fit. This should enable the operator to place the bracket securely in the appropriate position on the tooth without rocking. A poorly fitting base can result in unprecise torque, angulation, and rotation once the full-sized wire is completely engaged. In order to produce an appropriately fitting bracket base, the manufacturer needs to pay attention to a number of factors.

The buccal surfaces of individual teeth show only very minor anatomical variations. An anatomically preformed bracket base is ideal and will fit well in the majority of cases. A precisely fitting base needs to take into account both the occlusal–gingival and also the mesiodistal curvature of the tooth surface. This is a challenge from the manufacturing point of view as a tooth surface is not built with a uniform curvature and a single radius like a circle, where a bracket can be positioned anywhere on the surface with equally good results. A tooth surface has many diverse radii and curvatures, depending on the location on the surface—and this applies to both the occlusal–gingival and mesiodistal directions (**Fig. 2.2**).

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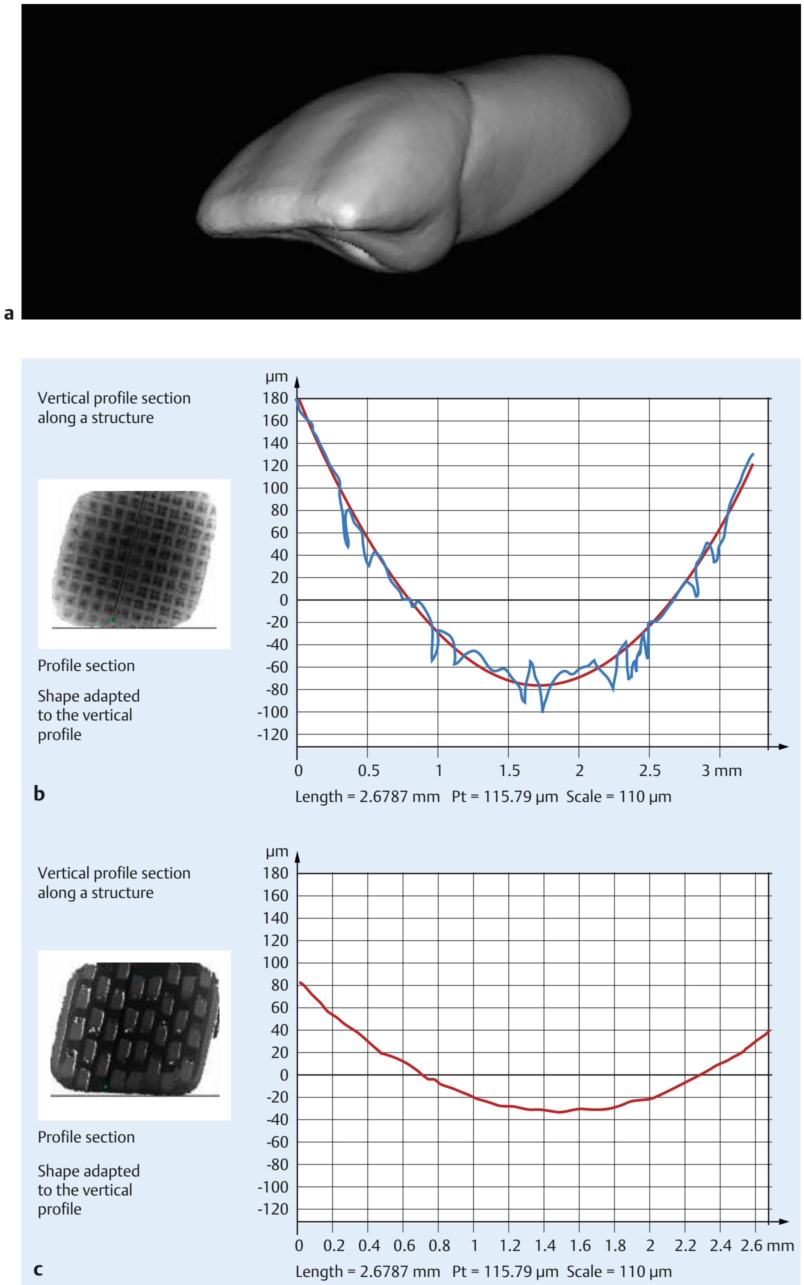

Fig. 2.2 a–c This three-dimensional scan of an incisor shows that the buccal surface has multiple different radii instead of a uniform curvature (**a**). The surface curvature differs in both horizontal and vertical directions. In practical terms, this means that the radius of the incisor decreases from mesial to distal, whilst it increases in the occlusal–gingival direction. The three-dimensional scan of a bracket designed to fit on a central incisor (**b**) shows that its base is quite curved (vertical section). This incongruence leads to poor fitting on the tooth surface, which has to be compensated for with composite material. A different bracket base (**c**) shows improved bonding characteristics by adhering more closely to the results of the tooth-shape analysis. Comparison of the two bracket bases illustrates the differences between the curvatures of different brackets (**b, c**).

The importance of the congruence of the bracket base and the surface of the tooth has been known for a long time. Most manufacturers now offer brackets that have different surface characteristics with increased or decreased convergence. These convergences were originally determined by cross-sectional analysis of teeth that were cut in order to measure the curvature. It was therefore only possible to obtain a small number of convergences per analyzed tooth; due to the intense labor involved, the sample size per tooth type was usually small. Despite this, the results from the original studies are still often used in the manufacturing of bracket bases even today. Modern three-dimensional reconstructions of tooth surfaces are nowadays used in computer models and this method allows better correlation of the bracket base with the actual surface of the teeth, due to the increased number of teeth that can be analyzed and averaged (**Fig. 2.3**). Some manufacturers use this technique to design and construct their bracket bases and therefore claim to produce better-fitting bracket bases than others, but it is important for the bracket base to be manufactured in such a way that the data obtained can be used in a meaningful way. This is most likely to be possible with metal injection molding (MIM) or ceramic injection molding (CIM). Both of these techniques allow the individualized and fitted shape to be transferred when the bracket is

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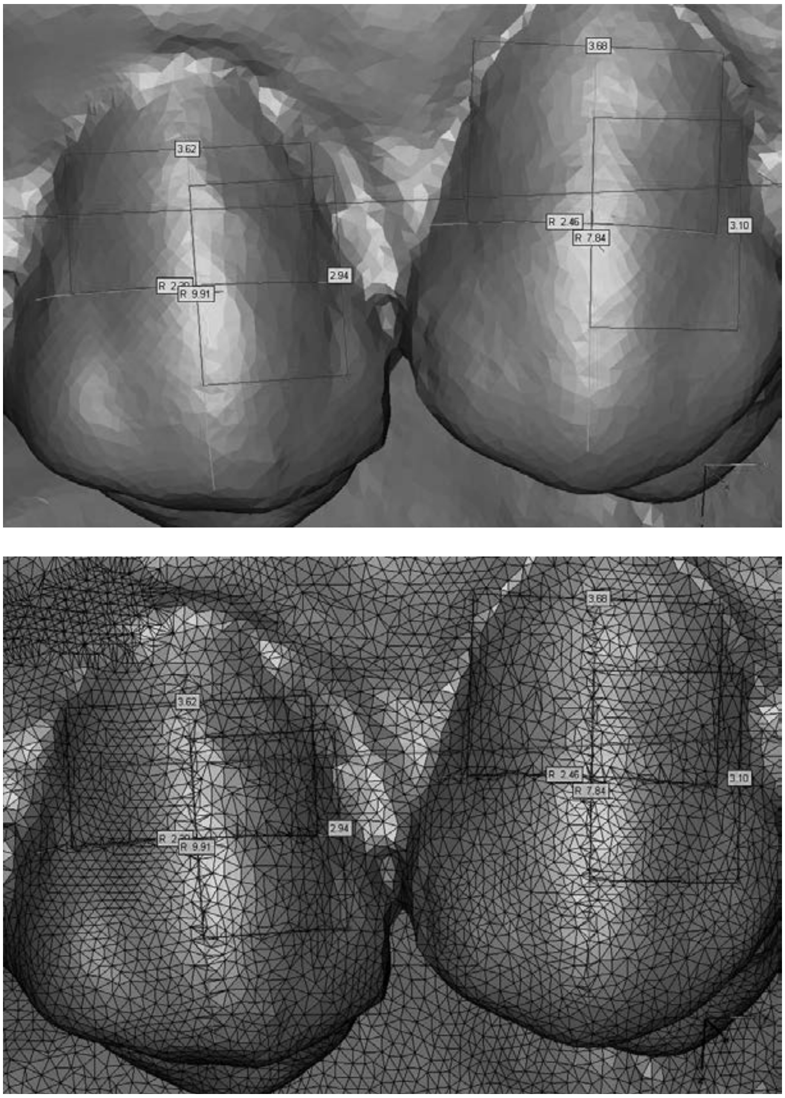

a, b

Fig. 2.3a, b Three-dimensional scanning makes it possible to collect morphological data for a large number of individual teeth and allows precise analysis of surface characteristics. Average values are calculated from this data and can help improve bracket base designs.

produced. A number of bracket manufacturers produce a bracket base from premanufactured plates, which are then bent into the desired shape. In a separate step, this bracket base is then connected to the bracket itself (see the section on "Bracket Body" below). It is not possible to produce the ideal surface characteristics that a bracket should have using these techniques. This is due to the very small size of the bracket base, resistance to deformation by the metal itself, and manufacturing issues with the application of forces to the small surfaces.

NOTE

Mismatches between the bracket surface and the tooth have to be compensated for by the adhesive, which may lead to poor bracket positioning and in turn result in incorrect tooth positioning.

Positioning errors can also result from canting the bracket or from migration of the bracket between positioning and polymerization. This may lead to poor slot orientation and in turn to undesired tooth movement (**Fig. 2.4**).

Bond Strength

The ideal orthodontic bracket adhesive should have two main properties: on the one hand, it should ensure a sufficient bond strength to be able to withstand the everyday stresses of mastication and manipulation. On the other hand, it should also allow easy removal of the bracket without damage to the enamel. As these two properties are diametrically opposed, orthodontic adhesives compromise by trying to deliver an adequate bond strength for most clinical situations—neither too strong nor too weak.

Most studies would agree that the minimum bond strength necessary for orthodontic treatment is in the

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