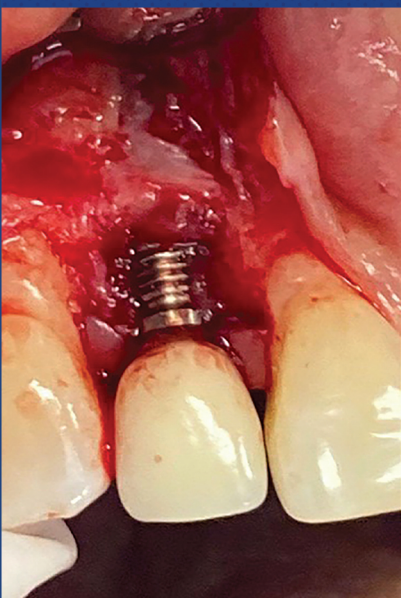


# Dental Implants

for Hygienists and Therapists

Ulpee Darbar



WILEY Blackwell

## Dental Implants for Hygienists and Therapists

# Dental Implants for Hygienists and Therapists

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## Glossary

- Abutment:** The component of an implant that interfaces with the implant fixture and the prosthetic entity. Retained with a screw or can be adapted for a prosthesis to be cemented. Made of titanium, alloyed metals, gold; zirconia; ceramic. They can be preformed and come as straight or angled or custom made.
- Analogue:** Replica of the implant fixture or the abutment which is used by the laboratory to make the prosthesis.
- Abutment driver:** Instrument used to connect the abutment to the fixture.
- Abutment healing cap:** A temporary cover used to protect the implant fixture head during the healing period.
- Abutment–implant interface:** The surface of contact between the implant fixture and the abutment.
- Abutment-level impression:** Impression of the abutment taken once the abutment is connected to the implant fixture either directly through conventional impressions or indirectly through an impression coping.
- Abutment Screw:** The screw used to connect the abutment to the implant fixture and has different features depending if it is a single crown or a bridge. It is torqued to the final position.
- Allogenic bone:** Bone from the same species.
- Alloplastic material:** Material of synthetic origin that does not have human or animal origin.
- Anti-rotation:** A feature that prevents rotational movement
- Barrier membrane:** A material used to exclude cells from invading into the defect allowing the preferred cells to grow into the defect. When used technique is called guided bone or tissue regeneration. Membrane can be resorbable or non-resorbable. Made of collagen or synthetic derivatives which are resorbable or titanium or polytetrafluorethylene (PTFE) which are non resorbable.
- Bicortical stabilisation:** Used when both the superior and inferior cortices of bone are used to obtain stability of the implant.
- Bisphosphonate-related osteonecrosis of the jaw (BRONJ):** Also called medication-related necrosis, it is the necrosis of bone related to bisphosphonates.
- Bone to implant contact:** A term used to describe the direct contact of bone to the implant.

- Bone to implant interface:** The line of separation between the living bone and implant fixture surface.
- CAD-CAM:** Computer-aided design computer-aided manufacture used to plan, design and construct implant restorations. It forms part of the digital workflow.
- Connective tissue attachment:** The mechanism by which the connective tissue attaches to the implant.
- Countersinking:** Bone preparation of the crestal aspect using special drivers to allow subcrestal (below the bone) placement of the implant shoulder.
- Cover screw:** Fits over the implant head to protect it when the gum tissue is closed over it and the fixture is submerged.
- Dental implant:** A screw made of titanium that is screwed into the jawbone using specialised and specified techniques to resemble a tooth root.
- Diagnostic wax up:** Procedure in which the teeth are created to match the planned restoration and used in planning and also for construction of a radiographic and surgical guide.
- Digital workflow:** A workflow that uses digital technology to convert analogue structures into a digital format.
- External connection:** The connection that protrudes on top of the implant fixture platform and connects the prosthesis to the fixture.
- Fixed prosthesis:** A prosthesis that is fixed to the implant fixture which the patient cannot remove for cleaning.
- Fixation screws and tacks:** Used to stabilise membranes or block grafts to the underlying bone.
- Fixture:** Endosteal dental implant.
- Guide drill:** The first drill used to open the cortical bone at the implant site during implant surgery.
- Guided bone regeneration:** Technique used to selectively allow bone cells to populate the defect.
- Healing abutment/cap:** Used after the first- or second-stage surgery to connect the implant fixture to the oral cavity.
- Implant stability:** Clinical evaluation of the implant assessing its degree of stability.
- Implant substructure:** The metal framework onto which the crown or prosthesis is connected.
- Impression coping:** A device used to register the position of the dental implant or abutment.
- Immediate loading:** The prosthesis is placed underload at the same time as implant fixture placement.
- Internal connection:** The connection which sits inside the body of the implant fixture and links the implant fixture to the prosthesis. It comes in different configurations.
- Peri-implant diseases:** Include peri-implant mucositis where there is reversible inflammation of the gingival tissues and peri-implantitis where there is irreversible loss of bone with inflammation.
- Prosthetic screw:** Screw used to connect the prosthesis to the abutment.
- Primary stability:** Mechanical stability achieved when the implant fixture is placed. Also known as the initial stability.



**Provisional restoration:** Temporary restoration placed whilst the tissues are healing.

**Radiographic marker:** A radio-opaque material incorporated into the radiographic guide to show the position.

**Radiographic stent/guide:** Used to direct the position of the tooth in relation to the underlying bone. Worn by the patient when having the radiograph or CT scan.

**Regeneration:** Technique used to reconstitute tissues lost through disease.

**Surgical guide/template:** Used during the surgical implant placement to guide the placement of the implant fixture to be placed in the correct restoratively driven position and angulation.

**Torque driver:** Instrument used to apply the correct level of tightening force (torque) to the screws.

**Two-stage surgery:** When the implant fixture is covered over by the soft tissue and a minor procedure is undertaken to uncover the fixture.

# 1

## History of Dental Implants

The concept of dental implants dates as far back as 2000 BC when carved bamboo pegs were originally used to replace missing teeth. A dental implant is a prosthetic device made of alloplastic material implanted either into the oral tissues beneath the mucosal and/or the periosteal layer and/or within the bone to provide retention and support for a fixed or removable prosthesis. When inserted into the bone, the implants are called endo-osseous implants.

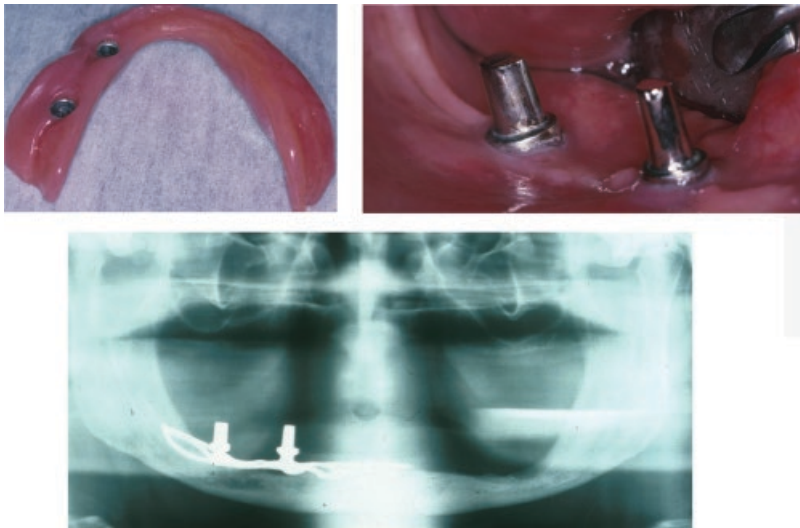
Around 3000 years ago, Egyptians used metal pegs to replace teeth, and it was not until the 1930s the concept of modern implantology came into existence with progressive development of methods used to replace missing teeth (Table 1.1). The materials from which dental implants are made should be biocompatible, corrosion resistant, and encourage bone ingrowth and biofunctionality.

During 1939–60s the concept of the ‘in the bone’ (endosteal) implant arose with the first cylindrical endo-osseous solid screw implant with threads both internally and externally with a smooth gingival collar and healing cap being placed. Following this during the 1940s, a spiral stainless steel post type endosseous implant with a design that allowed bone to grow into the implant emerged and Dahl in Germany, around the same time, introduced the concept of the subperiosteal implant with mucosal inserts (Figure 1.1). This implant was made of cobalt-chromium molybdenum with a direct impression of the struts on the ridge crest taken to construct the denture. Throughout the 1940s–50s variations on the original Dahl design emerged in an attempt to make the provision of implants simpler and included the use of vitallium implants in 1948, the Linkow endo-osseous blade vent implant in 1966 with different designs for the maxilla and mandible (Figure 1.2), the ramus frame implant in 1970, made of stainless steel (Figure 1.3) and mandibular transosseal implant which engaged the lower border of the mandible with inserts projecting into the mouth to support a prosthesis (Figure 1.4). The ramus frame and transosseal implants were predominantly designed for patients with atrophic mandibles who had difficulties wearing dentures and were used to aid denture retention to improve function.

The key challenge with these older implant systems was biocompatibility, the lack of fusion to the jawbone resulting in recurring infections after a period of time and the complex surgical techniques needed to insert the implants leading to limited use aimed at

**Table 1.1** Progressive Development of Methods used for Tooth Replacement.

500–2500 BC	300–600 AD	800 AD	1500–1800s	1809	1913
<ul style="list-style-type: none"> <li>– Egyptians tried splinting teeth using gold ligature wires</li> <li>– Eustracians used customised soldered gold bands from animals and oxen bone</li> </ul>	<ul style="list-style-type: none"> <li>– Phoenicians used Ivory to carve teeth used as bridge replacements</li> <li>– Mayans introduced the concept of implants when they tried to use ‘Pieces of Shells’ as implants to replace mandibular teeth; Radiographs taken in the 1970s of such mandibles show compact bone formation around the implants (bone similar to that around blade implants)</li> </ul>	<ul style="list-style-type: none"> <li>Hondurans used a stone implant and placed this in the mandible</li> </ul>	<ul style="list-style-type: none"> <li>Europeans used cadaver teeth for allotransplantation</li> </ul>	<ul style="list-style-type: none"> <li>J Maggiolo inserted a gold implant tube into a fresh extraction socket and after healing a crown was added; other materials used were silver capsules, corrugated porcelain</li> </ul>	<ul style="list-style-type: none"> <li>Dr Greenfield placed a ‘24-gauge hollow latticed cylinder of iridio-platinum soldered with 24-karat gold’ as an artificial root to ‘fit exactly the circular incision made for it in the jawbone of the patient’</li> </ul>



**Figure 1.1** Subperiosteal implants in the mouth.

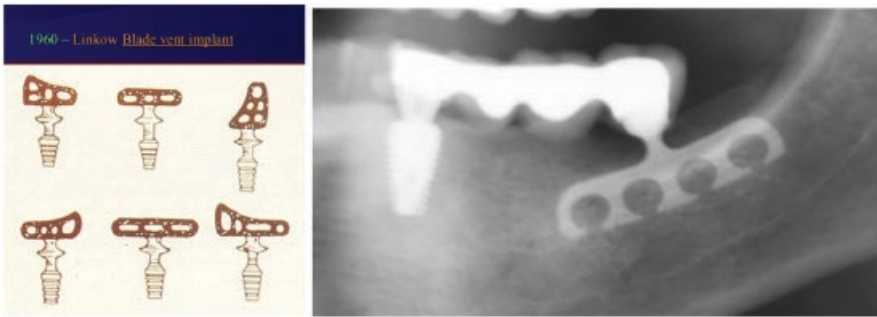


Figure 1.2 Blade vent implants.

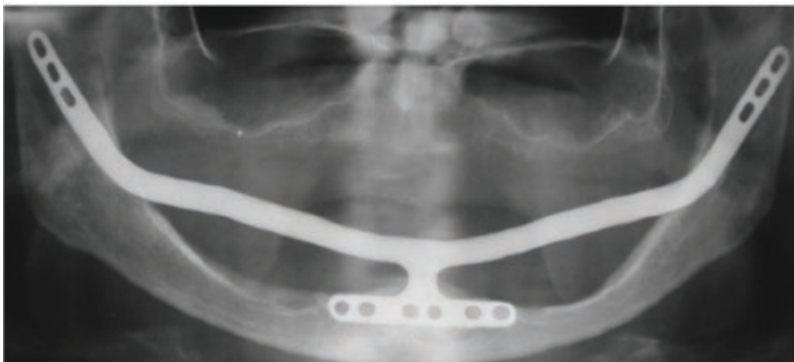
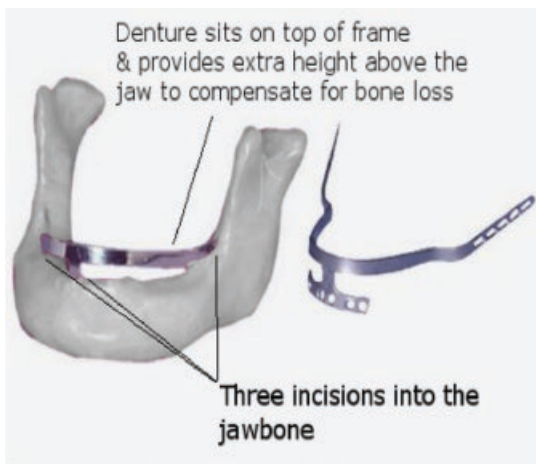
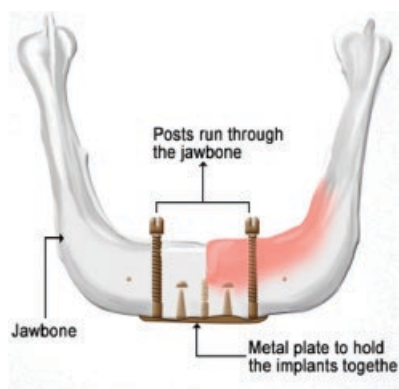


Figure 1.3 Ramus implants.



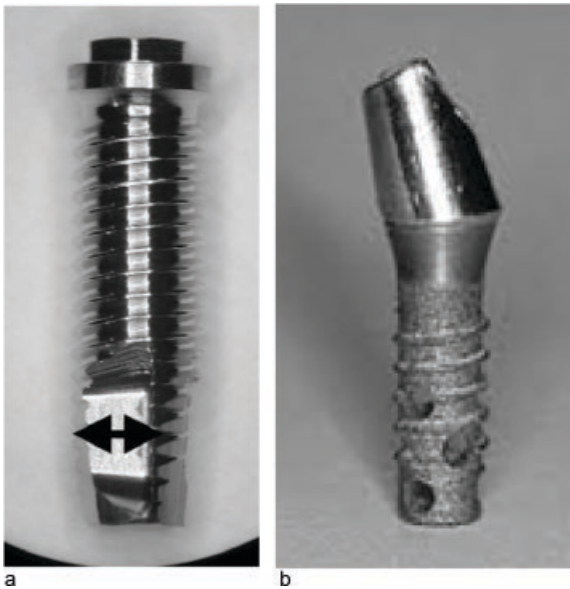
**Figure 1.4** Mandibular transosteal implant.

specific patient groups. Additionally, the infections led to secondary issues with bone resorption compounding the existing issues.

In the 1950s, an orthopaedic surgeon, Per Ingvar Branemark, accidentally found, during the study of bone healing and regeneration, that a titanium cylinder fused together with the bone in the femur of a rabbit. He hypothesised that this fusion could be utilised in field of dental implants and placed the first dental implant made of commercially pure titanium in a human volunteer in 1965. This finding introduced the concept of osseointegration which forms the basis of today's endo-osseous dental implants. Osseointegration became accepted as a worldwide phenomenon when the concept was launched at the Toronto World Conference in 1982. At around the same time, whilst Branemark was looking at a two-stage threaded implant, Schroeder and his group were independently evaluating the use of a one-piece root form implant made with a hollow design and a roughened surface (Figure 1.5a, b).

Since the introduction of osseointegration, in the late 1980s, as a predictable method of tooth replacement, growing confidence and predictability has led to the widespread use of dental implants moving from edentulism to partial edentulism including single teeth and those with extensive tissue and tooth loss usually seen in patients who have suffered traumatic injuries and congenital anomalies (e.g. Hypodontia). This progressive change has led to the focus changing from improving function to include aesthetics and psychological well-being alongside the need to address patient expectations.

Dental implantology continues to evolve with concomitant modification of implant screw designs, surfaces and techniques used for implant placement and restoration aimed at reducing integration healing times, optimising function and aesthetics alongside predictability. These changes have led to newer concepts for tooth replacement being considered which include the use of zygomatic implants in those with atrophic maxillae, the mini implants and the 'All-on-Four' concept whereby the teeth are extracted and implants placed and restored all on the same day. Additionally, the advent



**Figure 1.5** a, b: The Branemark two-piece implant fixture and the Shroeder one-piece hollow cylinder implant.

of digital technology has enabled clinicians and technicians to push this clinical envelop even further with digital systems being used for planning, surgical placement and restoration without any analogue interfaces being used. Whilst, we live in a fast-moving world driven by technology and systems geared to meet patient demands, the biological envelop in which we as clinicians have to work has seen little change and as clinicians we need to be cognizant of this challenge commonly referred to as ‘patient and site’ related factors.

Today there are in excess of 250 implant systems on the market with varying design features, many of which resemble either one or more features of the eight mainstream implant systems. Table 1.2 shows the development of different key implant systems since 1982.

## Key Learning Points

- Be able to describe the older systems, as patients may attend for treatment with these systems
- Being able to recognise the older systems to assist with management
- Be able to explain to patients possible problems and issues with infections
- Be aware of challenges associated with evolution of the concept of dental implants

**Table 1.2** Some of the Mainstream Dental Implant Systems.

1977	Branemark Implants
1982	Launch of Osseointegration
1982	Non-submerged implant system: ITI Corevent implant system
1985	Biocon
1987	IMZ
1989	3i
1990	Astra
1999	Straumann Synocta
Late 1990s	Frident (Frialit 2, Xive)
Early 2000	Ankylos and similar
Mid-2000 onwards	Modification of the earlier implant systems with newer surfaces, shapes and designs

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- 2 Branemark, P.I. and Zarb, G. (1985). *Tissue Integrated Prosthesis: Osseointegration in Clinical Dentistry*. Quintessence Publishing.
- 3 Rajput, R., Chouhan, Z., Sindhu, M., Sundararajan, S., and Chouhan, R. (2016). A brief chronological review of dental implant history. *International Dental Journal of Student's Research* 4 (3): 105–107.

## 2

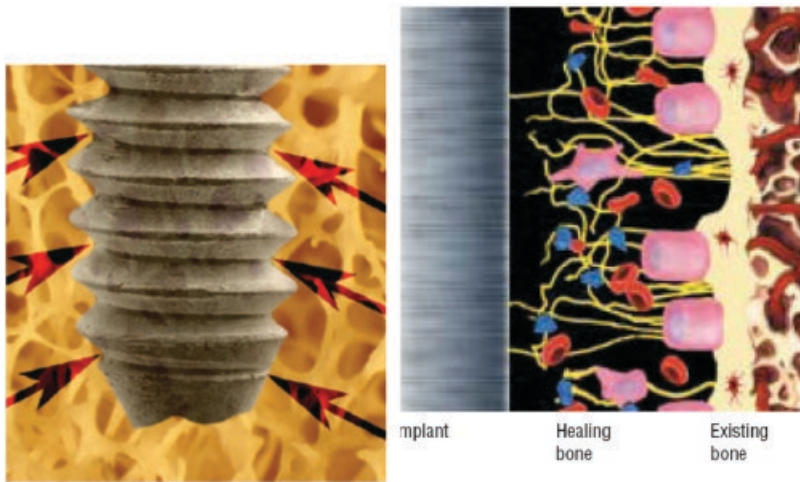
### Osseointegration

Osseointegration (OI) was first defined at the light microscopic level as a ‘direct structural and functional connection between ordered living bone and the surface of a load carrying implant’ (Branemark 1983). The phenomenon involves a complex interaction between the implant, bone and tissue interface (Figure 2.1). The process involves two stages with an initial biomechanical interlocking between the implant body and alveolar bone, called primary stability, followed by the second stage which involves the biological fixation of the implant through bone remodelling and apposition, called secondary stability, with each stage being influenced by various factors and steps being followed during the placement of the implant (Figure 2.2). Primary implant stability plays an essential role in successful osseointegration and is dependent on the implant geometry, the bone quality and quantity as well as the site preparation technique.

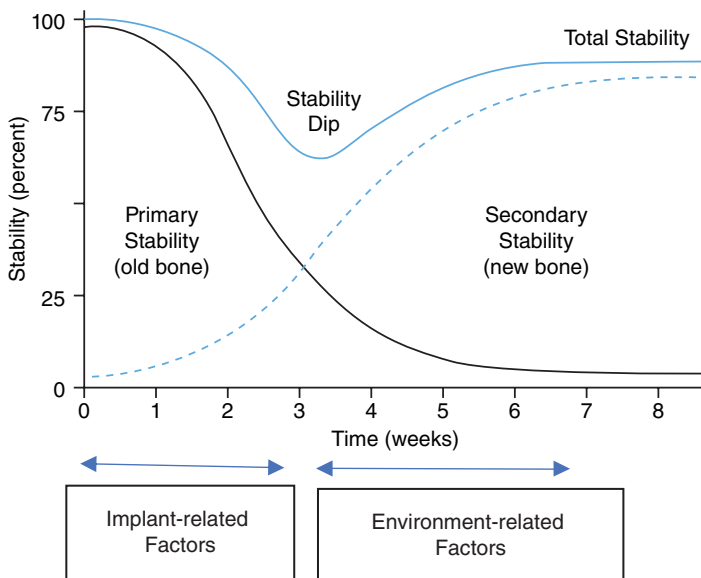
### Concept

The original concept of OI was redefined at the clinical level by Zarb and Albrektsson (1983) as a ‘time dependent healing process whereby clinically asymptomatic rigid fixation of alloplastic materials is achieved and maintained in bone during functional loading’. The histologic appearance resembled a functional ankylosis with no intervening fibrous or connective tissue between bone and implant surface (Figure 2.3). The first implants, known as ‘Branemark Implants’, were made of pure machined titanium surfaces and had to be covered over by the gum flap after surgical placement for at least six months to allow the screw to integrate into the jaw bone. Today with an improved understanding of the concept and changes in implant screw designs and surface modifications, the healing times have reduced with implants being restored at the same time as placement with healing periods of 0–8 weeks. Figure 2.4 shows the different healing time lines for dental implants and their restorations. The original clinical definition of osseointegration thus needs updating with removal of the word ‘time dependent’ as a fixed period of healing before loading is no longer an absolute requirement.





**Figure 2.1** Bone to implant contact in osseointegration.



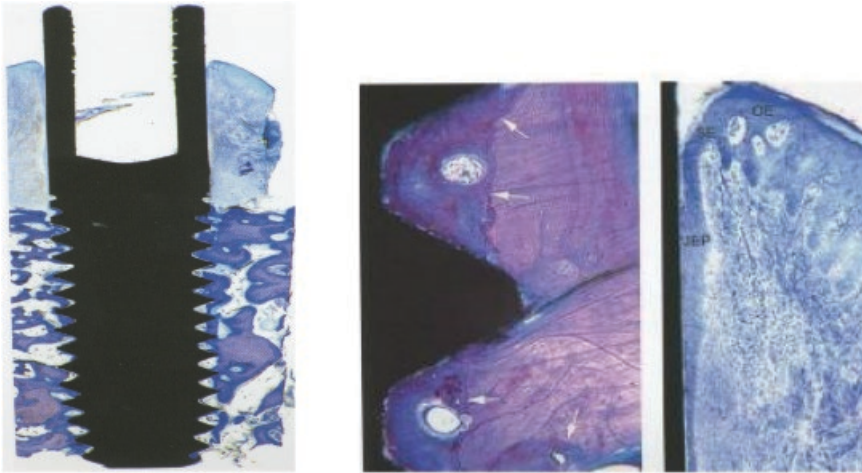
**Figure 2.2** Primary (mechanical) stability vs secondary (biological) stability.

## Factors Affecting Osseointegration

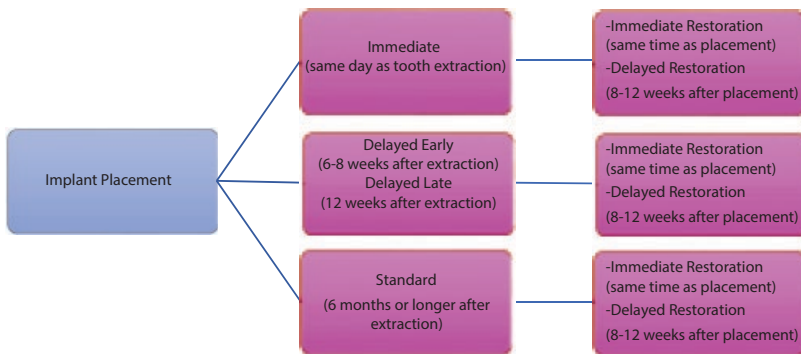
Factors affecting osseointegration can be divided into implant related and environment related (Table 2.1).

- **Implant-related factors:**

These factors primarily affect the mechanical interlocking of the implant and are thus fundamental to facilitating OI. They include the material of which the implant is made (biocompatibility), the design features of the implant and the macroscopic and



**Figure 2.3** Osseointegration showing the close interface of the implant surface to bone with no intervening soft tissue.



**Figure 2.4** Healing time lines for implant placement and restoration.

microscopic surface features of the implant. Progressive changes in these features have enabled reduced healing periods as a result of the improved primary stability at the time of implant placement.

- Implant Materials

The material of which the implant is made does not directly influence the mechanical stability of the implant but ensures biocompatibility.

- Commercially pure titanium (cpTI):

This material has excellent biocompatibility, and its bioactivity is related to the immediate formation of a stable and inert oxide layer on its outer surface when exposed to air. It is classified into grades 1–4 depending on the purity and processing oxygen content with Grade 1 being the most pure with the lowest oxygen content (0.18%) and Grade 4 being the least pure with the highest oxygen content (0.4%). The different grades contain varying amounts of contaminants such as iron for corrosion

**Table 2.1** Factors Affecting Osseointegration.

<b>Implant-Related Mechanical Stability = Primary Stability (Initial Period)</b>	<b>Environment (Host)-Related Biological Stability = Secondary Stability</b>
<p><i>Materials (Biocompatibility)</i></p> <ul style="list-style-type: none"> <li>● Commercially pure titanium</li> <li>● Titanium alloys</li> <li>● Zirconium</li> </ul> <p><i>Design</i></p> <ul style="list-style-type: none"> <li>● Shape</li> <li>● Threads</li> </ul> <p><i>Surface</i></p> <ul style="list-style-type: none"> <li>● Machined (turned)</li> <li>● Plasma sprayed/laser</li> <li>● Sandblasted</li> <li>● Acid etched</li> <li>● Anodised</li> <li>● Coated</li> <li>● Chemically treated</li> </ul> <p><i>Diameter and Length</i></p> <ul style="list-style-type: none"> <li>● Narrow, regular, wide</li> <li>● Short, standard, long</li> </ul>	<p><i>Status of the Host Bed</i></p> <ul style="list-style-type: none"> <li>● Vascularity</li> <li>● Quality of bone : Type I, II, III, IV</li> </ul> <p><i>Surgical Site Preparation</i></p> <ul style="list-style-type: none"> <li>● No overheating</li> <li>● Ample cooling</li> <li>● Technique</li> <li>● Sequential drilling</li> </ul> <p><i>Healing Periods</i></p> <ul style="list-style-type: none"> <li>● Influenced by above and need for augmentation</li> <li>● Post-operative trauma</li> <li>● Smoking</li> <li>● Aftercare</li> <li>● Prosthesis</li> </ul> <p><i>Loading Conditions</i></p> <ul style="list-style-type: none"> <li>● Immediate</li> <li>● Early</li> <li>● Delayed</li> <li>● Standard</li> </ul>
<b>Influenced by Operator Related Knowledge, Skill and Competence</b>	

resistance, aluminium for increased strength and reduced density and vanadium which scavenges the aluminium thus imparting corrosion resistance. Grade 4 cpTI has the highest strength, highest passivity and a modulus of elasticity comparable to bone and is therefore the material of choice for manufacturing dental implants. Its key disadvantages are the low wear resistance and grey metal shine through in patients with thin gingival tissues contributing to compromised aesthetics.

- Titanium alloys:  
The alloying of cpTI enhances the strength and wear resistance of the material.
- Titanium, Aluminium and Vanadium Alloy (Ti6Al4V):  
This alloy is mainly used for dental implants and contains 6% aluminium, 4% vanadium, up to 0.25% iron and 0.2% oxygen with the rest being titanium. The material has excellent fatigue properties and corrosion resistance with a low elastic modulus leading to a 'stress shielding' effect due to the mismatch between the implant material and surrounding

bone. The alloy releases small amounts of aluminium and vanadium ions and can be associated with allergic reactions, cytotoxic effects and neurological disorders. Implant systems made of titanium alloys usually tend to be slightly cheaper than those using cpTi.

– Titanium-Zirconium Alloy (Ti-Zr):

This alloy has been shown to be biocompatible, bioactive and mechanically stable and has comparable properties to cpTi with a reported tendency to significantly improve osteoblast adhesion to the implant surface. The ‘Roxolid’ implants manufactured by the Straumann Company are made of this alloy and have been used for more than five years with good success rates. The strength of the material enables smaller implant diameters to be made with internal connections.

● Zirconium/Ceramic

Zirconium, a ceramic biocompatible biomaterial, has gained popularity as an implant material due to its aesthetics and was first tested during the 1990s as an implant material. The oxide form of zirconium has the capacity to create OI of a lesser quality and etching techniques have been used to improve the quality and extent of the OI. There are two zirconium implants available on the market. The ‘Ceraroot’ implant is an acid-etched zirconium implant (Oral Iceberg) and Straumann Pure ZLA is also an acid-etched ceramic implant (Figure 2.5a, 2.5b).

● Implant Design

The design of an implant facilitates the primary stability during the placement of the implant and includes the shape and thread configuration of the implant. Other parameters such as diameter and length are also important and influence primary stability indirectly.

– Implant shape

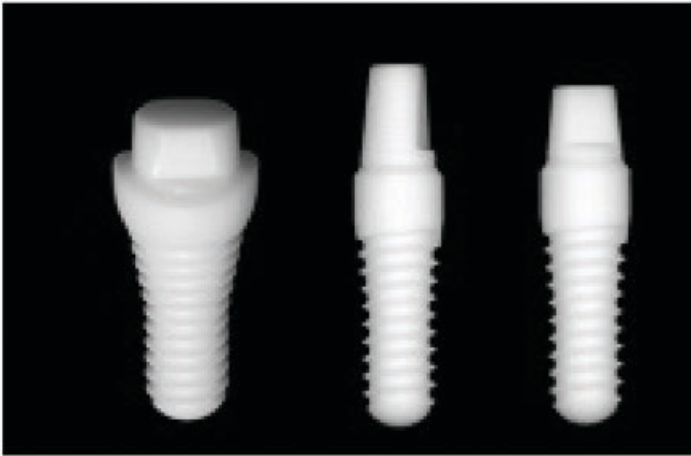
The implant shape ensures there is a good approximation between the bone and implant and facilitates force distribution to the bone. Three shapes, cylindrical, parallel sided and tapered, have been used with the cylindrical form implants manufactured as unthreaded implants inserted using a ‘press-fit’ action into the prepared site (Figure 2.6). These implants are no longer available due to compromised treatment outcomes. Parallel-sided and tapered/conical screw (also called threaded) form implants have been used with the former being more popular until recently where hybrid designs combining the features of both these shapes becoming more widely used (Figure 2.7). These hybrid implants are designed to increase the contact area between the implant and bone as well as relieving stress concentrations due to the different thread designs thereby improving the stability enabling reduced healing times (Figure 2.8). Most implant systems have introduced these ‘hybrid’ versions into their portfolio whilst still retaining the standard implant designs.

● Implant threads

The threads on a implant screw determine the degree to which the stability of the implant when placed is achieved and also facilitates the stress distribution to the bone. The degree of the stability achieved will be dependent on the profile and configuration of the threads called the thread depth and pitch (Figure 2.9). Screw form implants have threads that are



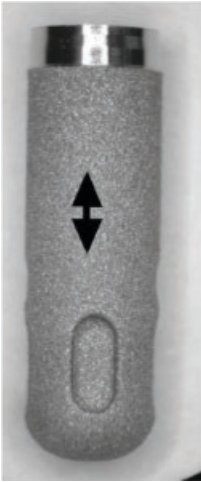
(a)



(b)

**Figure 2.5** a. b: Zirconium implants. a: Straumann. b: Ceraroot.

designed to engage into the alveolar bone thereby improving primary stability and the sharper the thread pitch the better the stability. This is a feature that has been introduced into most implants systems as the surgical provision of implants has moved towards immediate and delayed placement. Figure 2.10 shows the different thread configurations and shapes which influence the stress concentration on the bone. Most implant systems adopt a combination of thread designs incorporating microthreads coronally with a tapering thread profile, double and triple thread configurations and increased thread width, pitch and depth. The use of microthreads coronally is deemed to increase the contact between the coronal bone and implant thus reducing the risk of coronal bone loss whereas, changes in thread pitch and depth are aimed at providing faster penetration into the bone thereby reducing risk of trauma to the bone. These changes in design have enabled improved primary stability thus contributing to faster osseointegration and healing (Figure 2.11a, 2.11b).



**Figure 2.6** Cylindrical implants used with a press fit action for placement (IMZ implant with TPS-coated surface).



**Figure 2.7** Parallel-sided and tapered implants.

- **Implant Surfaces**

Surface topography of the implant influences the attraction of the osteoblasts to the implant surface with rough surfaces promoting osteogenesis by increasing the surface area over which the osteogenic cells can adhere and cellular activity takes place. The surface roughness can be described at the macroscopic (few mm to microns), microscopic (1–10 microns) and nanometric (1–100 nm) level with the different levels having a profound effect on cellular healing accelerating the migration and proliferation of osteoblasts thereby improving the rate of osseointegration. Machined surface implants also



**Figure 2.8** Hybrid-designed implant (parallel sided at the top; tapered apically).



**Figure 2.9** a, b: Different implant thread configurations. a: The machined implant on the right was the first implant and the change in the shape and design as well as the thread pitch is evident as you go from left to right. b: Different thread shapes and pitch (macrodesign).

known as ‘turned’ surfaces were the first to be used and whilst at a macroscopic level, the surface looked smooth, under the microscope the processing of the implants still created some irregularities on the surface. The irregularities increase the surface area and different techniques have been used with these implants being largely superseded by implants with different surface topographies. The two main methods used to modify the implant surface are either by removing material on the surface or adding material on the surface. The former include acid etching, blasting with an abrasive material and treatment with



**Figure 2.10** Shows the progressive change in an implant thread design: The implant on the left shows the change in the depth and pitch of the threads, and the implant on the right shows the microthreads at the top aimed at improving the contact with the coronal bone.

lasers whereas the latter includes hydroxyapatite coating and titanium plasma spraying, oxidation or anodization and deposition of nanoparticles by physical or chemical methods. Figure 2.12 shows the different surface topography and modifications associated with these methods. Plasma spraying and laser treatments are no longer used as the rate of integration was similar to that of the machined surfaces; however, laser treatment to promote gingival tissue adhesion, called the ‘laser lock’ has been used as a feature in one of the implant systems who state that this locking mechanism leads to an integration of the gingival tissue fibres to the surface. Table 2.2 shows the different generation of dental implants categorised according to the surface roughness.

- **Implant Diameter and Length**

Implant diameters have changed over the years to enable improved profiles of the restorations. Early dental implants were available in one diameter (3.75 mm); however, as different types of teeth started being replaced with implants, the need for different diameters became evident to avoid ‘mushroom’ designs of the prosthesis. Implant diameters, today, fall into three groups, narrow (2.8–3.4 mm diameter), regular (3.75–4.1 mm) and wide (5.00–6 mm) with each group matching the type of tooth being replaced thus enabling the appropriate emergence profile of the restoration to maintain gingival tissue health (Figure 2.10) with each diameter group being colour coded enabling the correct components to be used. Implant lengths of up to 20 mm were advocated to achieve bicortical stabilisation where the border of the jaw bone and the alveolar crest was engaged to obtain stability. This concept has now evolved with the modified implant surfaces promoting healing with the average implant length being 11–13 mm. Whilst



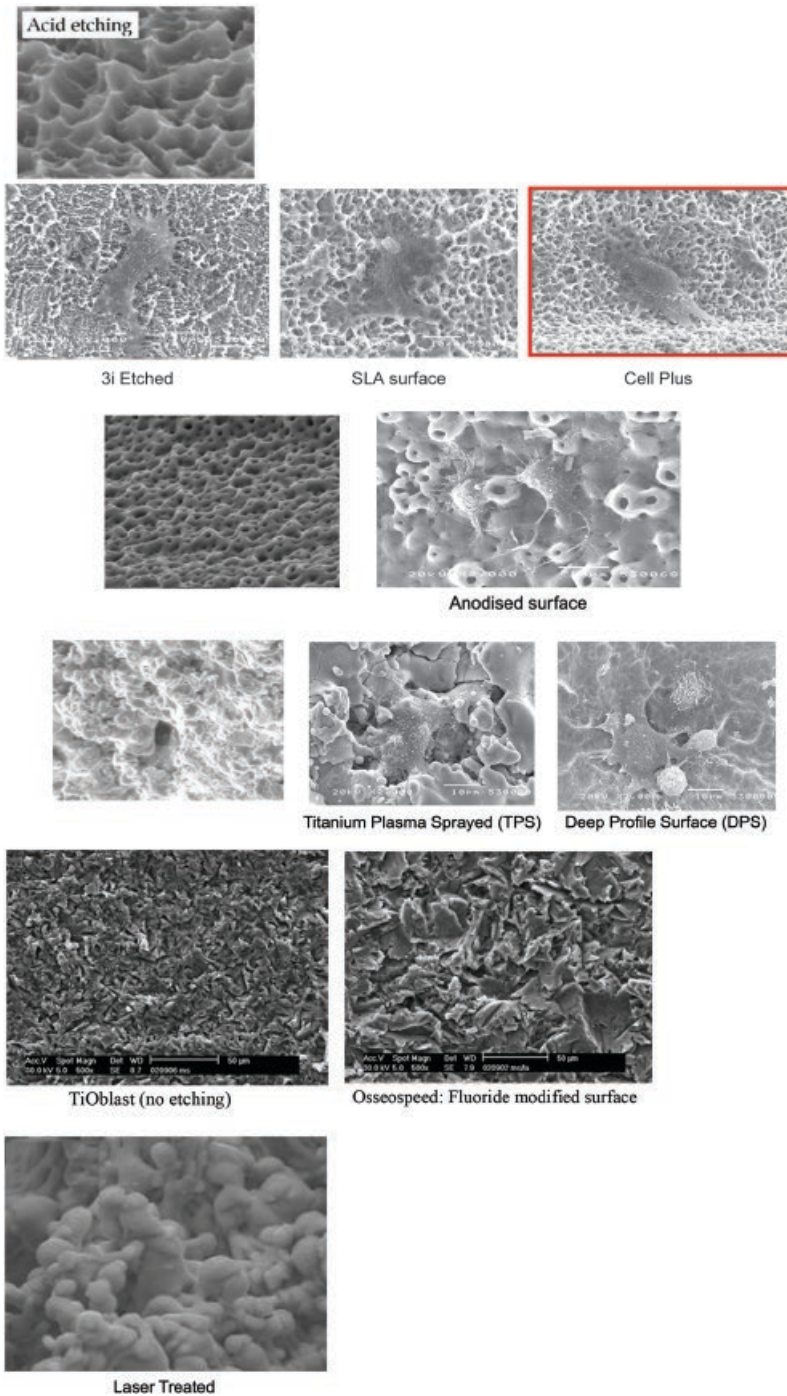


**Figure 2.11a** The progressive change in the implant shape and thread profiles.



**Figure 2.11b** Range of different implants.

previously, the shortest implant fixture advised was 7 mm, today the use of even shorter implant fixtures with lengths of 4–6 mm have become available as sites with compromised bone height are being considered for implant placement thus avoiding the need for advanced surgical interventions (Figure 2.13a, b). The use of the different diameters and lengths should be based on the outcome of the treatment plan agreed and finalised with the patient.



**Figure 2.12** Electron Micrographs of the different surface topographies; acid etch, grit blasted, grit blasted and acid etched, anodised, plasma sprayed and laser treated. The SLA surface if both acid etched and grit blasted.

**Table 2.2** Different Generations of Implant Systems with the Surface Modifications.

Generation	Surface Treatment	Type of System	Implant System
First	None	Blades, subperiosteal, ramus, transosteal	
Second	Weak	Machined (turned) Titanium plasma sprayed (TPS) Coated	Old Branemark (Nobelbiocare); Old Straumann  Old IMZ
Third	Strong response	Moderately roughened surfaces Sandblasted and etched  Etched Anodised Blasted Laser ablation	Straumann SLA Dentsply Frialit and Friadent  Biomet 3i Nobelbiocare TiUnite Dentsply Astra TioBlast Biohorizons Laser Lok
Fourth	Optimal response	Chemically active Fluoride coated Calcium phosphate coating Bioactive glasses and bisphosphonates	Straumann SLA Active Dentsply Astra Biomet 3i Experimental



**Figure 2.13a** Implant diameters to match the type of tooth being replaced giving a better emergence profile for the restoration.



**Figure 2.13b** Different implant lengths.

- **Environment-Related Factors**

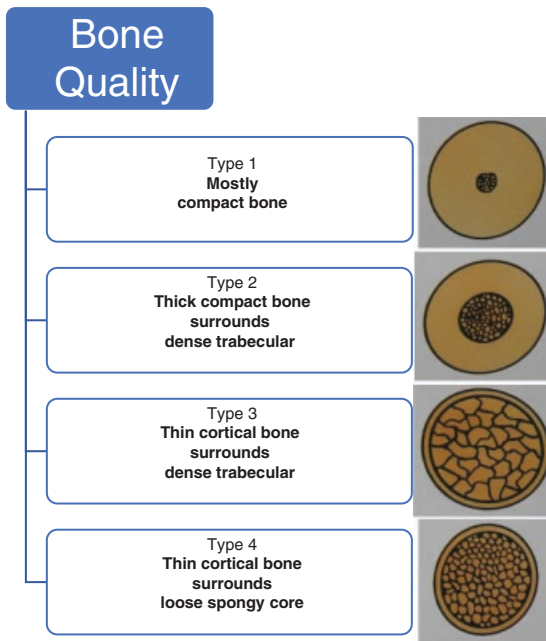
These factors influence the second phase of the osseointegration process during which the secondary stability of the implant is achieved. They include the status of the host bed, the surgical technique, healing period and loading conditions which determine the vascularity and the stability of the blood clot during the initial healing phase.

- **Status of the host bed**

The host bed is the alveolar bone and the surrounding soft tissues into which the implant is placed. The health of these tissues is crucial in determining how well the implant will integrate into the bone. Once the implant is placed, good vascularity (bleeding into the site) is needed to facilitate blood clot formation and remodelling of the cells into bone forming cells. In sites where the blood supply is compromised or reduced, the rate of osseointegration will be compromised due to the lack of bone-forming cells. The vascularity of the bone is dependent on the bone quality which is assessed by the ratio of the cortical to the cancellous bone and is described as Type 1, which is dense with little cancellous bone and Type IV which is soft with predominantly cancellous bone (Figure 2.14). Type 1 bone has poor vascularity due to the reduced number of bone cells and specialised techniques using a ‘screw tap’ are needed during the site preparation to minimise the risk of bone necrosis caused by pressure and overheating during placement. Type 4 bone is like ‘quick sand’ and has good vascularity but poor density and thus modifications, such as using specialised tools, e.g. bone condensers, during site preparation are needed to ensure that primary stability of the implant is achieved. Any movement of the implant or the blood clot during the initial healing period will lead to fibrous tissue formation and loss of osseointegration. Smoking affects the vascularity of the soft tissues and the bone and thus has a negative outcome on healing and therefore the quality of osseointegration but has also been associated with a higher risk of complications.

- **Surgical Technique**

The surgical technique is of paramount importance in determining predictability of osseointegration ensuring that the site is not overheated to more than 47°C during site preparation. This is achieved by the use of sharp drills, used sequentially at recommended speeds ranging from 800rpm to 1200 rpm depending on the implant system



**Figure 2.14** The different types of bone quality described by the ratio of the cortical to cancellous bone.

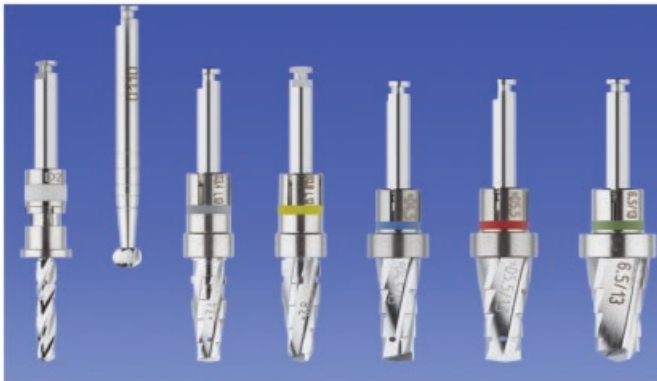
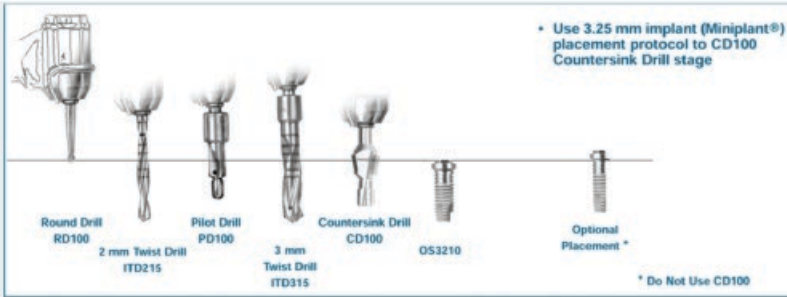
used. Throughout the drilling must be controlled with copious water cooling and minimal pressure to enable atraumatic site preparation. The cortical plate is usually perforated using a small round bur or sharp drill followed by gradually increasing diameter twist drills preparing the site to the required implant depth and diameter. The final drill is usually slightly smaller than the implant diameter which helps ensure good approximation of the implant surface to the bone (Figure 2.15). Parallel-sided implant placement advocates an intermittent drilling action, whereas the tapered or Hybrid designs, have matching drills that need to be used with a slight modification. Overprepared sites will either compromise the stability of the implant or cause trauma to the bone leading to failure of integration.

- **Healing period**

The healing periods with the early implants were crucial and could range up to six months; however, today with the newer generation implants, healing periods have reduced with implants being placed and restored on the same day. However, in all cases, treatment planning of the case is critical to the successful outcome of the implant placement and treatment and cases where extensive augmentation has been undertaken may still need 6–8 months for healing.

- **Loading conditions**

The loading of implants was restricted to six months with the early machined implants; however, loading protocols today have changed with immediate loading and loading within six weeks of placement being frequently applied. The time at which the implant



**Figure 2.15** a, b, c: Drill sequence showing the incremental change in drill shape. a shows the parallel-sided drills with the line diagram; b shows the drills for a tapered implant and c shows the drill sizes alongside the implant diameters.

can be loaded will be determined by the quality of the bone and the primary stability obtained as well as the extent of augmentation undertaken at the time of implant placement. Loading protocols today are determined by the factors outlined above, but still remain crucial in the initial healing period. Inappropriate loading at the incorrect time will affect the quality of the integration leading to implant failure despite the newer designs promoting excellent primary stability due to the aggressive thread designs. Thus the type of loading protocol to be used should be considered at the outset during the planning stage and balanced against what is realistically possible.

## Success Vs Survival

Implant treatment is influenced by a number of parameters. Success and survival are often used interchangeably to describe the outcomes of such treatment despite each term having a different meaning. A successful implant is one that is in situ and has not suffered any complications. It should, ideally, have been in function for at least five years with no history of either biological or mechanical complications and the surrounding tissues have remained healthy with stable marginal bone levels. Successfully placed implants will undergo 1.5 mm marginal bone resorption after placement during the first year of function followed by 0.1 mm annually thereafter depending on the type of placement and the technique used at placement. The bone remodelling around one piece implants (tissue level) is slightly lesser in the first two years with the annual remodelling being 0.1 mm as with the two-piece implant (bone level) systems. Marginal bone loss is one of the main criteria used to define success of dental implants. The criteria initially proposed by Albrektsson et al. (1986) are shown in Table 2.3a, and since this time others have included bleeding and peri-implant tissue health. Based on these criteria, success rates ranging from 90% to 95% over 10 years have been reported. To describe success, the criteria used must include information on the implant fixture, the peri-implant soft tissues, the prosthesis and patient satisfaction. Table 2.3b summarises the studies that have reported on success in these different categories, and it is evident that when a comprehensive evaluation of all the criteria that would define success are pooled together, there is a decrease in the reported success rates highlighting the fact that a successful implant has multiple factors that influence the outcome. A surviving implant, on the other hand is one that remains in situ with a history of inflammation, or evidence of infection or complications such as fracture. Survival rates of dental implants range from 89% to 96% over 10 years with 94.6% reported over 13 years with 1.3-mm marginal bone loss. Although the overall implant success and survival rates have been noted to be 88.0% and 97.2%, respectively, bone loss was evident in all 88% of the surviving implants. The reported data on survival and success rates needs to be considered with caution due to the disparate outcome measures used between studies with some reporting success rates of 74% and survival rates of 100%.

A degree of variation is observed between different implant systems and the case complexity with lower survival rates reported in patients with a history of periodontitis and those who smoke. Thus defining success around implants is complex and includes an interchange between implant fixtures (design, surface), patients

**Table 2.3a** Criteria for Success as Suggested by Albrektsson et al. 1986.

1.	An individual unattached implant that is immobile when tested clinically
2.	Radiography does not demonstrate evidence of peri-implant radiolucency
3.	Bone loss that is < 0.2 mm annually after the implant's first year of service
4.	No persistent pain, paraesthesia, discomfort or infection
5.	By these criteria success rate of 85% at the end of a five-year-observation period and 80% at the end of a 10-year period are the minimum levels for success

**Table 2.3b** Reported Success Criteria for Dental Implant-Retained Prosthesis [1].

Success Criteria	Descriptor	Fixed Complete Prosthesis (six Articles)	Overdenture (five Articles)	Fixed Partial Denture (eight Articles)	Single Crown (10 Articles)
Implant Level	Pain*	4	5	5	7
	Annual bone Loss < 0.2 mm thereafter*	2	3	4	3
	Radiolucency	3	3	5	7
	Mobility*	5	5	6	8
Peri-implant Soft Tissue Level	Probing depth > 3 mm*	2	1	2	2
	Suppuration*	3	3	5	6
	Bleeding	2	0	0	0
	Swelling	1	0	0	0
Prosthetic Level	Recession	1	0	0	0
	Minor complications (chairside approach)	2	0	0	0
	Major complications (failures)	2	0	1	0
	Aesthetics*	1	0	0	0
Patient Satisfaction	Function*	1	2	3	3
	Discomfort/ Paraesthesia*	4	4	1	4
	Satisfaction with appearance*	1	0	4	1
	Ability to chew	1	0	0	0
	Ability to taste	1	0	0	0

\* = Most commonly used criteria



(expectations, soft tissue, bone, social and medical history) and operators (experience, knowledge, competence).

Failure of implants is described when the implant, irrespective of the reason, has to be removed or has fallen out. The loss of an implant is multifactorial and includes site-, operator- and patient-related factors. Implant loss of 6% in the first year, 10% in the first 10 years and 12% in the 15 years after surgery has been reported. Table 2.4 summarises the factors affecting implant success rates.

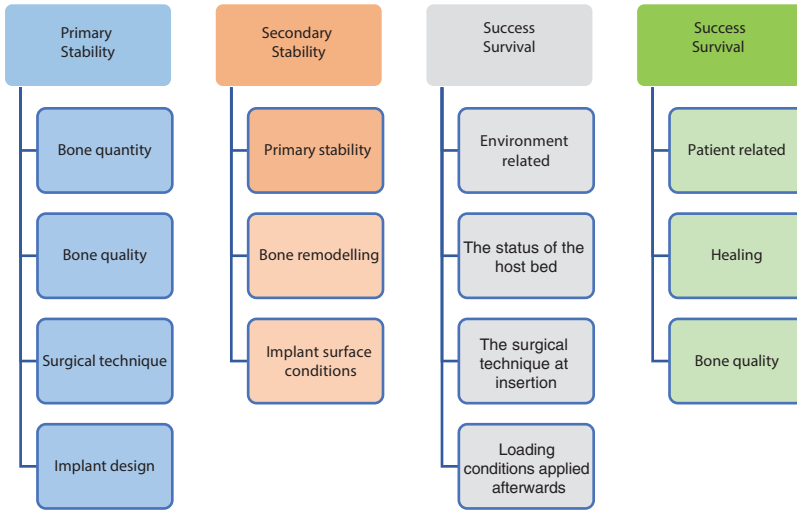
## Newer Concepts

As the clinical envelope for tooth replacement has been stretched, the search for newer and more simpler ways of replacing missing teeth in patients with advanced bone loss has been explored. Implant companies are always on the lookout to provide solutions to challenging issues, and the following ideas have been introduced to help overcome some of these challenges especially in patients with advanced bone loss wishing have a fixed solution or a solution that optimises their function and well-being.

- All on 4 or All on 6

This idea was introduced in an effort to help patients with severe atrophy in the posterior regions where there was limited bone or for those who did not want to pursue sinus lift surgery or major bone grafting with onlays. The missing teeth are replaced with a prosthesis that is retained on four or six implants and successful outcomes are dependent on stringent treatment planning. The provision of this type of treatment involves teamwork with the hygienist/therapist being a key member of this team along with the laboratory technician. It is usually considered in patients with all missing teeth, patients with periodontally compromised teeth and extensively carious teeth and teeth that are grossly broken down. The challenge with the concept relates to the patients compliance especially if their teeth have resulted in such a state, how well would they look after their implants.

The philosophy promotes the provision of fixed screw retained prosthesis on the same day for the entire upper or lower jaw following extraction of the teeth and placement of four implants (sometimes six implants) introducing the philosophy of 'teeth in a day'. The dense bone in the anterior part of the mouth is used to place the implants, and the posterior implants are placed at an angle 35–45 degrees to avoid the sinus cavities in the upper jaw and the inferior dental canal in the lower jaw (Figure 2.16). The fixed prosthesis is made from acrylic or composite fused to the titanium, monolithic zirconium or porcelain bonded to a cobalt–chromium frame. Treatment planning is crucial and incorrect planning will result in overload on the implants leading to bone loss and failure. Patient-related factors play a key role and should be considered carefully especially as patients are transitioning from their own teeth to teeth retained on implants. The prosthesis will usually be bulky and speech could be an issue, and parafunction may become a challenge especially in patients who have had teeth that are mobile. As the proprioception around implants is different to that around teeth, patients may generate excessive biting forces without realising it due to the lack of feedback that occurs with teeth that

**Table 2.4** Factors Affecting Implant Success Rates.**Figure 2.16** The all on four concept.

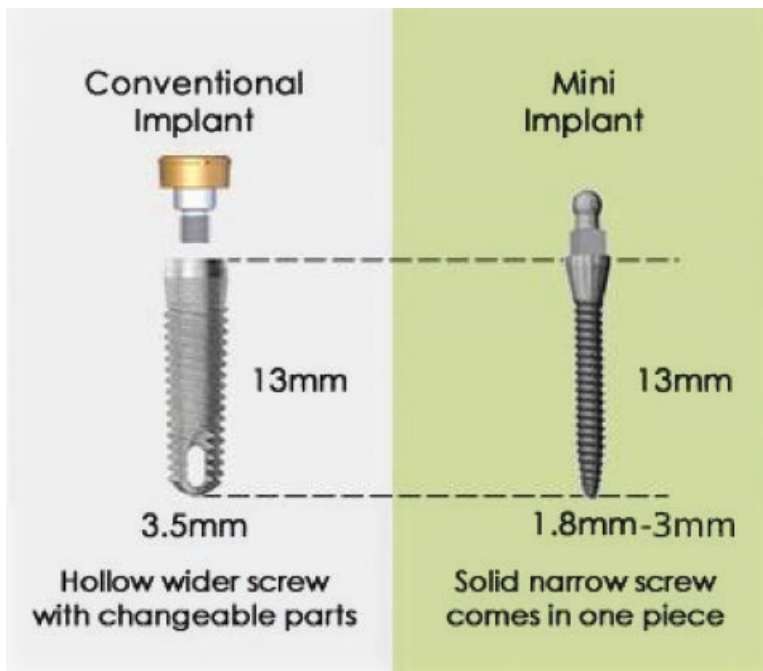
are supported by a periodontal ligament. Thus, these patients will generate higher biting loads resulting in possible fracture and failure especially if the patient has a tendency to parafunction. Whilst successful, with success rates of upto 95% being reported over 10 years, the main complications relate to the unsupported teeth beyond the implants breaking off as a result of excessive stresses and failure of the implants. The philosophy originally introduced by Nobelbiocare, is now offered by all other implant systems within their portfolio.

- Mini Implants

These implants have been used as an alternative to regular implants where there is inadequate bone width. They are a solid one piece screw with a diameter smaller than a traditional implant and can be very thin with diameters of 1.8 mm. The integral ball ended top protrudes out of the gum and can be used to retain dentures and bridges. They are simpler to use and do not have a separate abutment so the restoration is also much easier. As a result the implants are cheaper, however, carry a high failure rate. Due to the size, depending on the use, multiple implants may be needed (Figure 2.17). Their use must be carefully considered against the anticipated outcomes.

## Key Learning Points

- Describe the concept of Osseointegration
- Explain the factors that affect Osseointegration
- Discuss the role of different surface
- Interpret challenges they face with implant patients based on underpinning knowledge
- Consider the importance of host-related factors in affecting healing and integration



**Figure 2.17** Mini implants compared to standard implants.

- Evaluate the parameters of success, survival and failure and be aware of the limitations of published data
- Describe the alternative concepts

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