An increased uniform amount of coronal dentin significantly amplifies the fracture resistance of endodontically treated teeth, regardless of the post system used or the choice of material for the full-crown restoration34. A recent article by Coppede et al demonstrated that friction-locking mechanics and the solid design of internal conical abutments provided greater resistance to deformation and fracture under oblique compressive loading when compared to internal hex abutments35. These two “seemingly” disparate observations define the inherent continuum between natural tooth engineering and the principles of engineering necessary to orthobiologically replicate the native state.

The use of a ferrule or collet and a bonded or intimately fit post-core to restore function and form to an endodontically treated tooth is analogous to the use of a long, tapered friction fit interface with a retaining screw (Morse taper), to secure an abutment to a fixture. In both cases, the role of contact pressure between matching surfaces to generate frictional resistance provides a locked connection. This has been shown to affect the long-term stability of crestal bone support for the overlying gingival tissues and maintains a healthy protective and esthetic periodontal attachment apparatus36.

Human symmetry

The Roman architect Vitruvius’ (Marcus Vitruvius Pollio) description of the perfect human form in geometrical terms was a source of inspiration for Leonardo da Vinci, who successfully illustrated the proportions outlined in Vitruvius’ work ‘De Architectura.’ The result, the Vitruvian man, is one of the most recognised drawings in the world and is accepted as the standard of human physical beauty. Vitruvius theorised that the essential symmetry of the human body, with arms and legs extended, should fit into the perfect geometric forms; the circle and the square. However, Leonardo Da Vinci recognised that the circle and the square were only tangent at one place, the base. Observe the insert in Fig. 8. The stabilising platform for the human outlined form begins at that tangent; the intersection is graphically analogous to the structural configuration of platform switching. In geometry, an oval is a curve resembling an egg or an ellipse. Architects and engineers have used smooth oval curves to support the weight of structures over an open space literally since the second millennium BC. These arches, vaults and domes can be seen in buildings and bridges all over the world, the most perva- sive example being the keystone arches used by the Romans for aqueducts and mills.

An arch directs pressure along its form so that it compresses the building material from which it is constructed. Even a concrete block is readily broken if you hit it on the side with a sledge. But under compression forces from above, the block is incredibly strong and unyielding. Many will remember the weight bearing tripod experiments from grade school where an egg acts as one of three supporting legs of a square section of wood bearing books as the load. The structure could support over sixty books, almost twenty pounds, before breaking the supporting egg. One need only look at the root trunk and coronal tooth structure of a multi-rooted tooth and it becomes apparent that strength of the tooth form is dependent upon an arch form for its integrity (Figs 8a & 8 b).

Optimal engineering

Is it possible for this natural feat of engineering to be biologically replicated to the design parameters of osses-integrated implants? There are a number of paradigms that continue to fuel debate in the dental clinical and scientific communities pertaining to the optimal engineering predicates for implant design. These include smooth vs. rough surfaces, submerged vs. non-submerged installation techniques, mixed tooth-implant vs. solely implant-supported reconstructions, Morse taper abutment fixation vs. butt joint interface and titanium abutments vs. esthetic abutments in clinical situations where esthetics is of primary concern.

The cone-screw abutment has been shown to diminish micro-motion by reducing the burden of component loosening and fracture. This enables the identification of the effects of the parameters such as friction, geometric properties of the screw, the taper angle, and the elastic properties of the materials on the mechanics of the system. In particular, a relation between the tightening torque and the screw pretension is identified. It was shown that the loosening torque is smaller than the tightening torque for typical values of the parameters.

Most of the tightening load is carried by the tapered section of the abutment, and in certain combinations of the parameters the pretension in the screw may become zero. This tapered abutment connection provides high resistance to bending and rotational torque during clinical function, which significantly reduces the possibilities of screw fracture or loosening.

Biomechanics

“The seed of a tree has the nature of a branch or twig or bud. It is a part of the tree, but if separated and set in the earth to be better nourished, the embryo or young tree contained in it takes root and grows into a new tree,” Isaac Newton.

Pressure on the cervical cortical plate, micro-movement of the fixture-abutment interface (FAI) as well as microleakage and colonization at and within the FAI are some of the pathologic vectors associated with osseous remodeling, both crestal and peripheral to dental implants37.

Occlusal considerations engineered into fixture design should enable optimum load distribution for permanent load stability during functional stress loading, reduce functional stress transfer to the interfacial tissues and enhance the biologic reaction of interfacial tissues to occlusally generated stress transfer conditions38. Future modifications to implant biomechanics should focus on designs wherein the osseous trabecular framework retaining the fixture will adapt to the amount and the direction of applied mechanical forces, cope with off-axis loading, compensate for occlusal plane to implant height ratios differences as well as adjusting to mandibular flexion and torsion39.

In this new era of implant driven treatment planning, fixtures should be engineered to support single crowns with cantilevers instead of implant/implant or implant/teeth connections for a span of any degree. These engineering design iterations will minimise high-stress torque load at the implant-abutment interface and oxidation with degrees of bone insufficiency.

The goal should be to biometrically replicate the natural state to the greatest degree (Figures 10a and 10b) in regard to load bearing capacity.

Measuring success

Stable crestal bone levels are the yardstick by which treatment success and health are measured in the oral ecological system, whether it relates to natural tooth retention or restorative and/or replacement rehabilitation. It is therefore surprising that the treatment outcome standards for switched and subcrestally positioned design demonstrated better stress based performances and lower risk of bone overload than the other implant systems evaluated.

Essential features

Platform switching, together with a stable implant-abutment connection are increasingly accepted essential design features required to reduce or eliminate early crestal bone loss. A bacteria-proof seal, a lack of micro-motion due to a long friction grip tapered channel and minimally invasive second-stage surgery without any major trauma for the periodontal tissues are also important factors in preventing cervical bone loss.
A pre-configured platform switched design has a significant impact on the implant treatment in esthetic areas as not only is the tissue biotype preserved, but it has been shown to osseo-integration accept crestal bone remodeling and resorption of up to 1.5 - 2mm during the first year following fixture placement and prosthetic environment 31.

The concept of "biological width" outlines the minimum soft tissue dimension that is physiologically necessary to protect and separate the osseous crest from a healthy gingival margin surrounding teeth and the peri-implant environment.

A bacteria-proof seal, the lack of micro-movement associated with a friction grip interface and a minimally invasive second-stage surgery (where indicated) without any major trauma to the surrounding teeth and the peri-implant tissues are also important factors in preventing cervical bone loss. The literature suggests that the stability of the implant/abutment interface may have an important early role to play in determining crestal bone levels 32.

Tarnow's seminal study on crestal bone height support for the interdental papilla clearly showed the influence of the bony crest on the presence or absence of papillae between implants and adjacent teeth 33. Twenty years later, logic dictates that anticipated early crestal bone loss and diminished, albeit continual loss, during successive years of function, should have been engineered out of the substitution algorithm for peri-implant tissues 34.

Platform switching: By default or by design

'There is no logical way to the discovery of elemental laws. There is only the way of intuition, which is helped by a feeling for the order lying behind the appearance,' Albert Einstein. Platform switching theorises that by using an abutment diameter of a lesser dimension than the periphery of the implant fixture, horizontal relocation of the implant-abutment connection will reduce remodeling and resorption of crestal bone after insertion and loading. The concept implies that peri-implant hard tissue stability will engender soft tissue and papilla preservation. Maeda et al. reported that stress levels in the cervical bone area peripheral to a fixture were reduced when a narrow diameter abutment was connected in comparison to a size commensurate with the fixture diameter 35.

The authors concluded that the biomechanical advantage of shifting stress concentrations away from the cervical area will diminish their impact on the biologic dimension of hard and soft tissue, expanding apically from the FAI (Fig 11a, 11b and 11c). The inherent disadvantage is that it shifts stress to the abutment screw with the potential for loosening or fracture.

Ericsson et al. 36 detected neutrophilic infiltrate in the connective tissue zone contacting the implant-abutment interface. The facility by which platform switching/shifting reduces bone loss around implants has been investigated by Lazzara et al. 38. The authors hypothesised, that if the abutment diameter matches that of the implant, the inflammatory cell infiltrate is formed in the connective tissue contacting the microgap created at the FAI.

If an abutment of narrower diameter is connected to wider neck implant, the FAI is shifted away from the outer edge of the implant, thus diminishing inflammatory cell infiltrate away from bone. Hypothetically, less crestal bone loss is expected and an increased implant-abutment disparity allows more stable peri-implant soft tissue integration.

Baggi et al. conducted a finite element analysis experiment to define stress distribution and magnitude in the crestal area around three commercially available implants - ITI Straumann® (Institut Straumann AG, Basel CH), Nobel Biocare (Nobel BioCare AB, Göteborg SE) and Ankylos® (Dentsply-Friadent, Mainzheim, DE) 39. Numerical models of maxillary and mandibular mar- row bone segments were generated from computed tomography images and local stress vectors were introduced to allow for the assessment of bone overload risk. Different crestal bone geometries were also modeled.

Type II bone quality was approximated and complete osseous integration was assumed. It was concluded that the Ankylos C/X implant based on its platform be enhanced by osseous generation over the collar of the fixture (Figs 12a and 12b)34,35.

The endodontic implant algorithm parallels the question, which came first, the chicken or the egg as an example of circular cause and consequence. It could be reformulated as follows: 'Which came first, A that can't come without X? or Y that can't come without Z?' An equivalent situation arises in engineering and science known as circular reference, in which a parameter is required to calculate that parameter itself. This is the essence of foundational dentistry.

Nature wisely created a structure that could harmoniously interpolate hard and soft tissue, act as the portal of nutrition and communication for the body and be the gatekeeper on guard and in function throughout our lifetime. As such, our role is to ensure that however we reengineer nature, we must adhere to its rules, its logic and fundamentals.

The best evidence

This is not an easy task, as filtering out the best range of sources, presenting clear, comprehensive analyses and incorporating patient experience is a Herculean task. In many ways, this is analogous to Alice's Adventures in Wonderland as much of what we do grows 'curiouser and curiouser' as each new innovation demands that we go through the looking glass and determine what Alice found there.