


Form and Function of Implant Threads in Cancellous Bone

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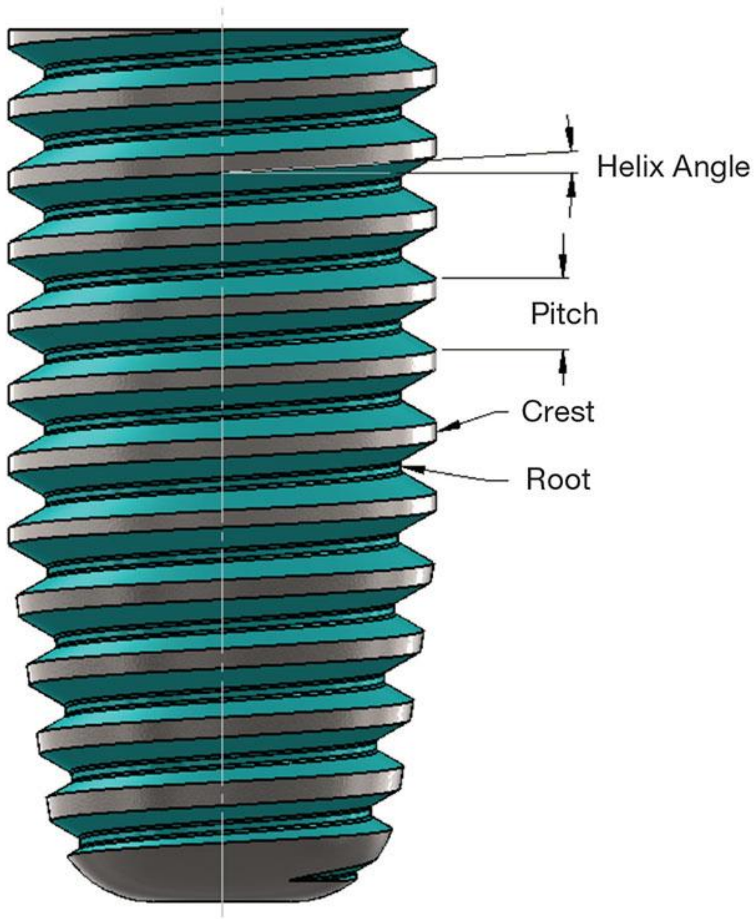
The external threads on dental implants are designed to maximize initial contact, enhance surface area and facilitate dissipation of stresses at the bone-implant interface.[1] The geometric characteristics of the thread influence how stresses are transferred from the implant to the bone. Sufficient initial contact with surrounding bone is important to facilitate primary stability of the implant. Macro enhancements to the surface area of the implant from the thread geometry itself increase potential bone apposition and both the primary and secondary stability of the implant.

Primary stability is defined as the capacity of the implant to withstand loading in axial, lateral and rotational directions.[2] Primary stability is influenced by the mechanical engagement of the implant with the surrounding bone after insertion, by bone quality and by the drilling protocol. Initial implant stability obtained after implant insertion is critical to the success of the implant.[3] At the time of placement, the assessment of primary stability may also serve as a guide for determining treatment protocol: immediate, early or delayed loading.[3]

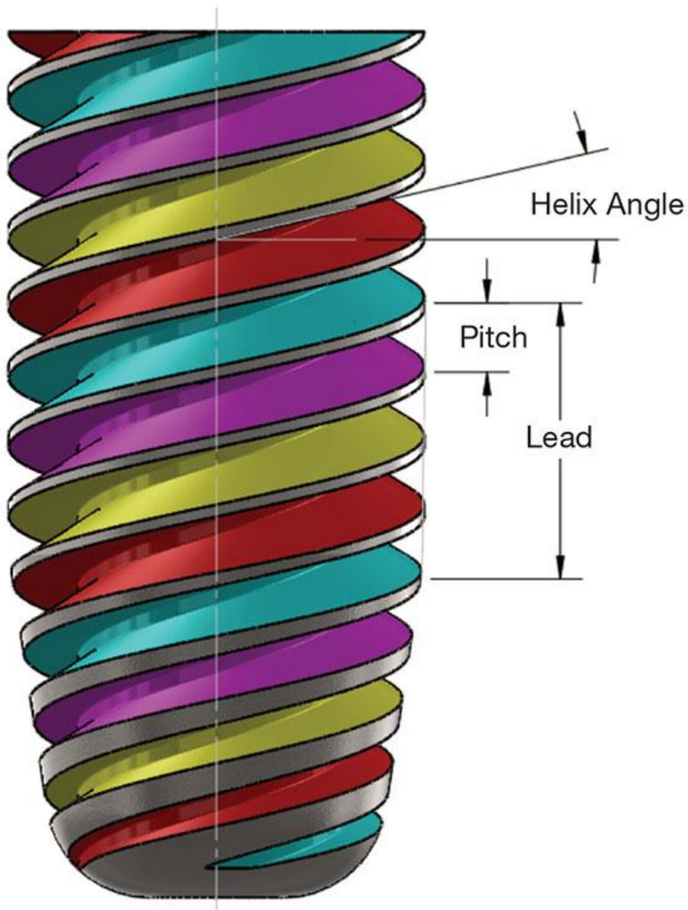
Secondary stability refers to the increase in stability due to regeneration and remodeling of the bone at the implant interface. Adequate primary stability is a prerequisite for secondary stability.[2]

Thread Characteristics
Threaded implants convert rotary motion into linear motion to advance the implant into the osteotomy site. Dental implants on the market today come in many thread configurations, which share characteristics common to screw thread forms (Fig. 1). These characteristics include:
Crest – The outermost surface joining the two sides of the thread.
Root – The innermost surface joining the two sides of the thread.
Helix angle – The angle formed by a point on the side and the plane perpendicular to the axis of the screw thread.
Pitch – The distance from a point on one thread to a corresponding point on the adjacent thread, measured parallel to the axis.
Lead – The axial distance that the implant advances in one complete turn.
The thread pitch and lead are the same for one-start threads. For multiple-start threads, the lead is a multiple of the pitch. The lead of a two-start thread is twice the pitch; the lead of a three-start thread is three times the pitch, etc.

One-Start Thread

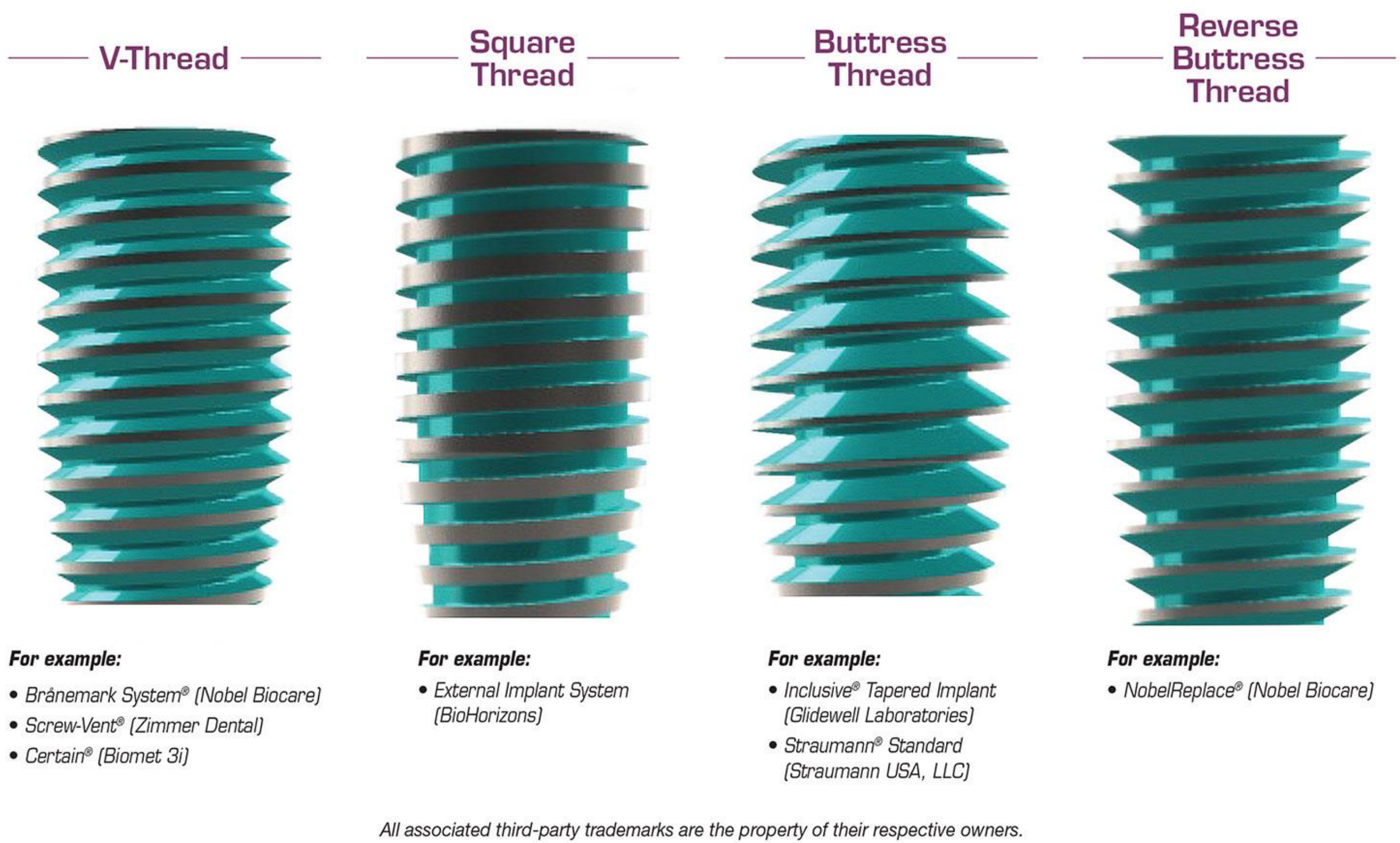


Four-Start Thread

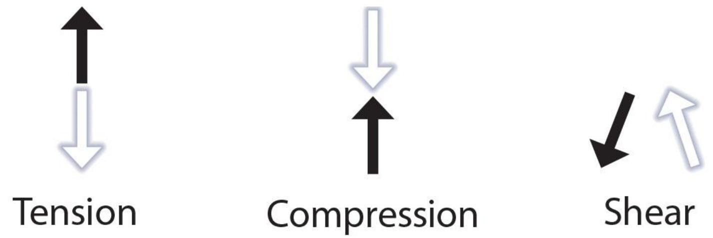


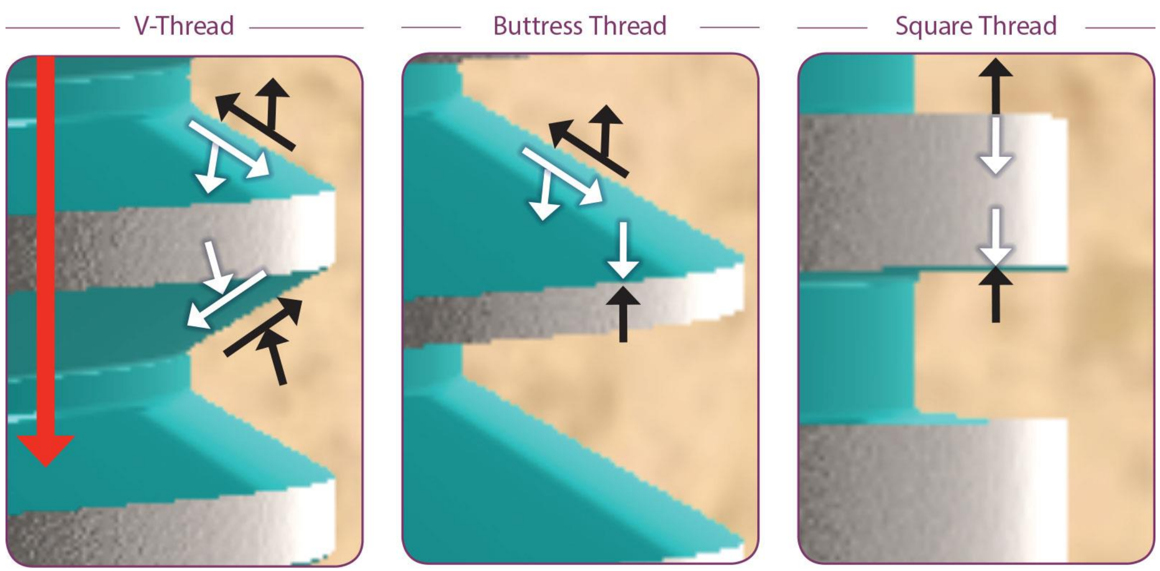
Thread Forms

Most dental implant thread forms can be classified as variations of threads developed for fastening and power transmission applications. Some of the thread forms used for screw-type dental implants are V-shaped threads, buttress and reverse buttress threads, and square threads. V-shaped threads were originally developed for fastening applications and to repeatedly translate machine parts against heavy loads4 (Fig. 2).



- **Direction of Forces**
- Threads are effective at increasing the initial contact with the surrounding bone and contributing to primary stability. However, they exhibit differences in how they transmit loads to the adjacent bone.
- Three primary types of loads are generated at the bone-implant interface: compressive, tensile and shear forces. Studies have shown that compressive forces lead to increased bone density and strength.[5] Tensile and shear forces have been shown to result in weaker bone, with shear forces being the least beneficial.[5] The amount of shear force increases as the thread face angle increases.[5]
- V-shaped screw threads have symmetrical sides inclined at equal angles. They are easy to manufacture and are widely used for mass-produced threaded fasteners (Fig. 3).
- Buttress threads have non-symmetrical sides and are very efficient in transmitting forces in a single direction along the axis of the screw head (Fig. 4).
- Square-form threads have symmetrical sides perpendicular to the axis of the screw head. They are very efficient at transmitting forces in both directions along the axis of the screw thread (Fig. 5).

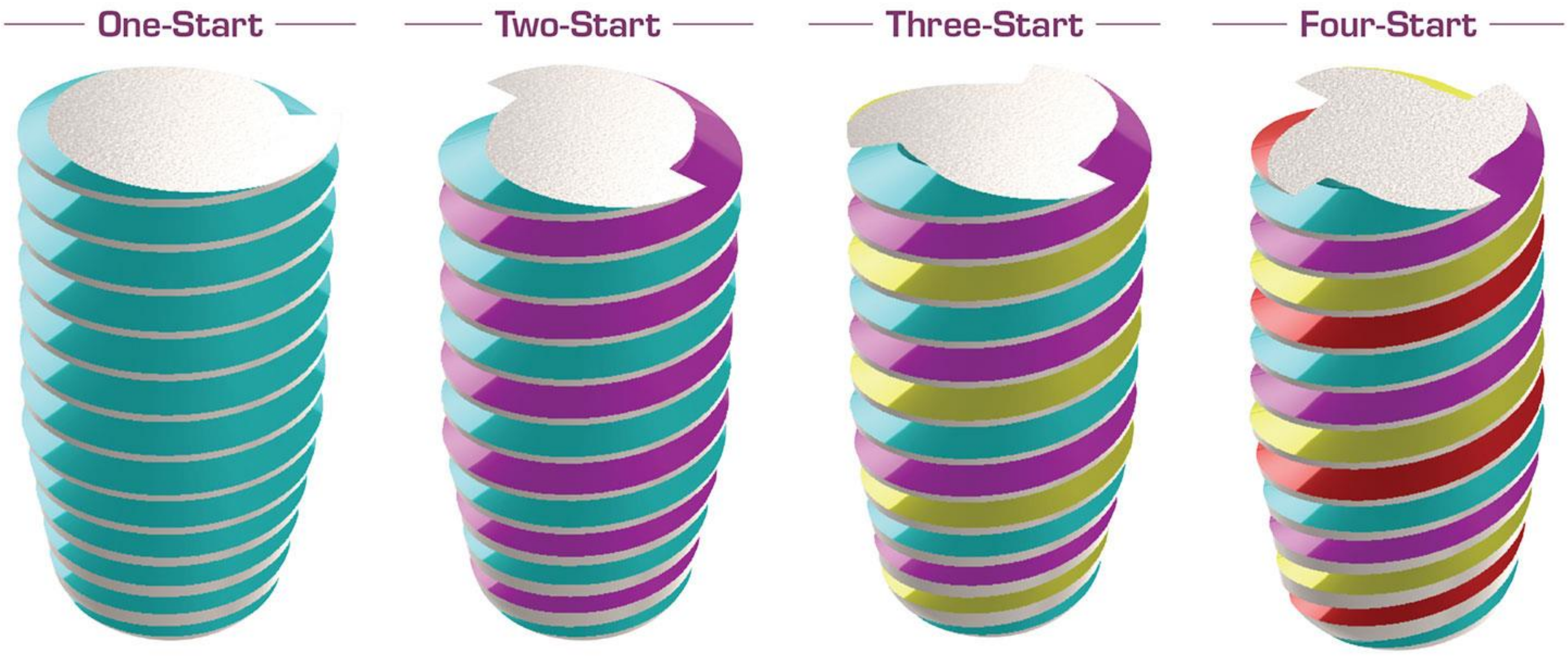




Multi-Start

In addition to the thread form, the thread lead and pitch are important thread characteristics that affect bone-implant contact, stress distribution and primary stability.

Some manufacturers have introduced multiple-threaded implants where two or more threads run parallel, one to the other (Fig. 6). These multiple-threaded implants allow for faster insertion; but, according to one FEA (finite element analysis) study, the most favorable configuration in terms of implant stability appeared to be the single-lead threaded implant, followed by the double-lead threaded implant. The triple-lead threaded implant was found to be the least stable.6



- V-threads, square threads and buttress threads are dental implant thread forms with a long history of successful use. These threads serve to dissipate occlusal loads into the bone surrounding the implant; however, they differ in form, inherent strength and in how they transmit forces. The multi-start iterations of threaded implants facilitate faster insertions at the apparent sacrifice of some primary stability. More research is needed to examine the interaction of primary stability and thread lead with single-start and multiple-start threads. V-threads are strong, but they transmit more shear forces to the surrounding bone. Square-thread forms transmit occlusal forces with less shear forces than V-threads, though they are not as strong as V- and buttress-thread forms due to their smaller cross-section at the base of the thread. Buttress threads are the strongest thread form for a given size because of their larger base cross-section, and because they minimize shear forces in a manner similar to square threads. They combine excellent primary stability with the best features of both V- and square-thread forms.

- References

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