Dental Implant Pitch Geometry

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Introduction:

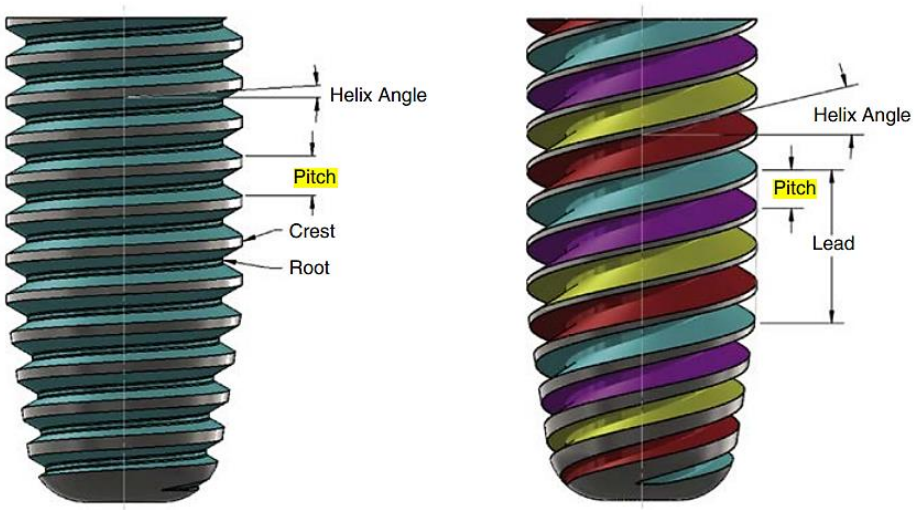
Primary stability of dental implants - one fundamental criteria for the success of dental implants, is influenced by implant geometry. Dental implants on the market today come in several different thread configurations; they can be understood using screw design terminology from engineering.

A screw thread, often shortened to thread, is a helical structure used to convert between rotational and linear movement or force. A screw thread is a ridge wrapped around a cylinder or cone in the form of a helix, with the former being called a straight thread and the latter called a tapered thread. A screw thread is the essential feature of the dental implant as a simple machine.

The crest is the outer surface of the thread, and it joins the two sides of the thread. The diameter measured around the crest is the **outer diameter** (OD) of the implant. The **root** is the inner surface of the thread, and it joins the two sides of the thread. The diameter measured around the root is the inner diameter (ID) of the implant. The helix angle describes the angulation between the wall of the thread and the perpendicular axis. (Mish's Contemporary implant Dentistry)[1]

Thread pitch can be defined as the distance from a point on one thread to a corresponding point on the adjacent thread, measured parallel to the axis. **Thread lead** is the axial distance that the implant advances in one complete turn. Greater pitch is more aggressive in cutting through bone. The lead is the axial distance that the implant is inserted with one complete turn. **Ormianer et al.**[3]

The geometry of the threads themselves influences stress distribution around the implant. Deeper threads seem to improve primary stability, particularly in bone of poor quality. (Misch)[1]



A) **Thread design** (Abuhussein H et al.)

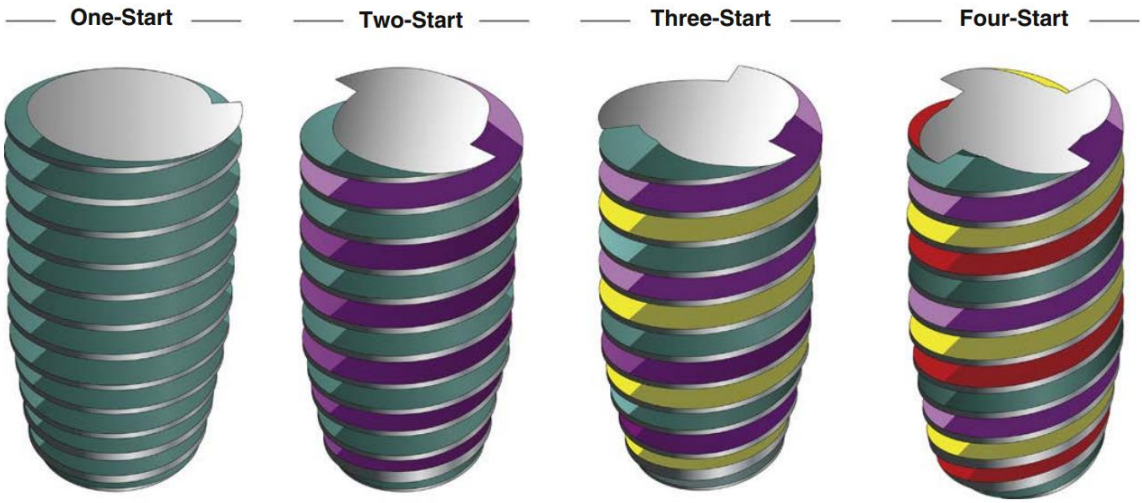
a) **Face angle**: Is the angle between a face of a thread and a plane perpendicular to the long axis of the Implant. In the implant literature the most suited face angle is that of the apical face where most of the loading forces are dissipated.

b) **Thread pitch**: Refers to the distance from the centre of the thread to the centre of the next thread, measured parallel to the axis of the screw. It may be calculated by dividing unit length by the number of threads. In implants with equal length, the smaller the pitch the more threads present.

c) **Thread helix angle**: In a single threaded implant the pitch equals the lead (the length of insertion of an implant every time when it is turned 360 degrees. Some manufacturers have introduced double or even triple threaded implants where two or three threads run parallel one to the other. This allows a faster insertion of the implant theoretically maintaining a pitch distance more favourable for the mechanical strength of the bone implant interface i.e. a triple threaded implant with a pitch distance of 0.6mm will be inserted 1.8mm every time it is rotated 360 degree. However, it has to be considered that as increasing the number of threads running parallel to one other, the thread helix angle changes. The most favourable configuration in terms of implant stability appears to be the single threaded one followed by the double threaded. The triple threaded was found to be the least stable.

d) **Thread depth and width**: Thread depth is the distance between the major and minor diameter of the thread. Thread width is the distance in the same axial plane between the coronal most and the apical most part, at the tip of a single thread. Both these designs have an effect on total implant surface area.

e) **Single/multiple thread start:** For a single-start thread, thread pitch and thread lead are the same. For multiple start threads the lead is a multiple of the pitch. For a two-start thread the lead is twice the pitch. A three-start thread has a lead that is three times the pitch.



Effect of Thread Pattern on Implant Osseointegration: Implant design, Thread shape and Pitch Distance are factors to consider when selecting implant characteristics that would aid in different clinical conditions.

Two main Hypotheses theorized the elements affecting the attainment and maintenance of Osseo integration. **(Abuhussein H et al.)**

1. The "**Biological Hypothesis**" focuses on the effect of bacterial plaque and host response patterns on implant survival.
2. "**Biomechanical Hypothesis**" emphasizes occlusal overload on the supporting bone and the effect of compressive, tensile and shear forces on Osseo integration.

Clinical Implications:

Increasing or decreasing Implant Thread Pitch:

1. Smaller thread pitch increases surface area and is thought to improve stress distribution in the surrounding bone. The initial mechanical anchorage and subsequent early endosseous integration in low-density bone could be improved by a reduction of thread pitch. The smaller thread pitch increased bone-implant contact and primary stability from the time of implant placement, and exhibited a higher quantity of newly deposited bone and a more regular and mature geometric distribution of bone tissue at the interface. A thread pitch less than 1.7 mm is more optimal for primary stability and osseointegration. **Orsini et al.**[5]

   However, because of the interaction between thread pitch, thread form, and thread depth, the optimum thread pitch for stress distribution in cortical and cancellous bone may vary. **Hassan et al**[6]

2. The effects of the implant thread pitch on the maximum von Mises stresses in jaw bones and the implant abutment complex using a finite element method determined that the thread pitches used in the analysis ranged from 0.5 to 1.6 mm and their results suggested that under axial load, the maximum equivalent stresses in cortical bone, cancellous bone, and implant-abutment complex decreased by 6.7%, 55.2%, and 22.3%, respectively, with the variation of thread pitch, and 2.7%, 22.4%, and 13.0%, respectively, under buccolingual load**. (Kong et al.)**[7]

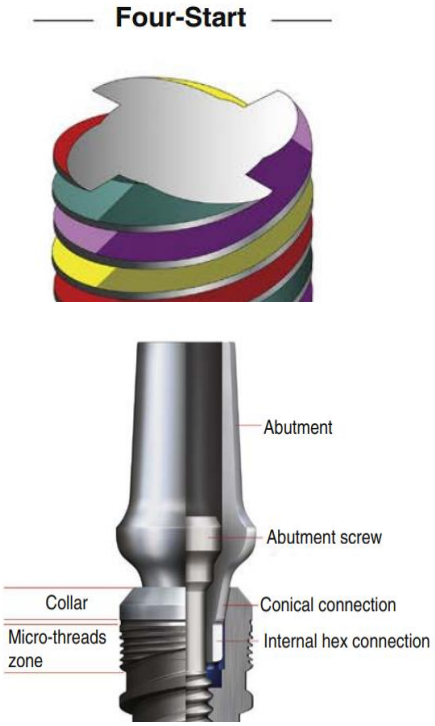
3. The cancellous bone is more sensitive to thread pitch than cortical bone, thread pitch played a greater role in protecting dental implant under axial load than under buccolingual load, and thread pitch exceeding 0.8 mm was the optimal selection for a threaded implant by biomechanical consideration. **(Kong et al.)**[7]

4. Optimal thread pitch parameters vary according to the thread shape. An optimal thread pitch was 1.2 mm for a triangular-thread implant, and a trapezoidal-threaded implant with thread pitch of 1.6 mm had the lowest stress value among trapezoidal-threaded implants. Each thread shape had a unique optimal thread pitch concerning lower concentration of bone stress. **Lan et al.**[8]

5. Thread width and depth, given the same implant body, a shallow thread depth would allow for an easier implant insertion. Deeper the threads the wider the surface area of the implant. Greater thread depth may be an advantage in areas of softer bone and higher occlusal force because of the higher functional surface area in contact with bone on the other hand shallow thread depth permits easier insertion into denser bone with no need for tapping. **Misch**[1]

6. Thread start, the advantage of a multiple-thread start implant is that the implant advances farther into the bone axially for each revolution. Implants with multiple start threads, the surface area is not increased because the pitch remains the same.

7. **Micro threads** are a series of threads of small pitch placed in the crestal or collar portion of the implant. Microthreads help spread forces from the collar of the implant and can assist with the maintenance of crestal bone height. (Misch)[1]



Conclusion:

Thread pitch relates to the placement torque and time required to place the implant. Implants with more threads also require more revolutions to place the implant. It will therefore take more time to insert implants with more threads, and placement will require more force in dense bone. Thread pitch is a factor that affects both primary stability and initial healing of the implant site. It is part of the overall implant thread parameters in combination with thread shape and thread depth. Varying the thread pitch affects stress distribution, primary stability, and the quantity and quality of osseointegration. (**Misch 4t Ed**)[1]

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