Dental implants are vastly used as replacements for natural dental roots. Over the last decades, dental implants have been proven to provide excellent solutions for patients, whose other choices were either to use a removable denture or to prepare natural teeth as abutments for dental bridges.  

During this time, a few factors were determined as critical for long term success, mainly: materials, surface characteristics, and implant stability. Initial implant stability in particular is linked with short and long term success rates.

Multiple implant designs are currently available. These designs differ in implant's body shape (cylindrical vs. conical), thread design; thread pitch and depth, and more. Aiming to provide designs that allow high initial stability through thread geometry, the industry changed from triangular, small pitch and small depth thread designs to more aggressive designs, with sharp and square shaped threads, and with higher pitch depth threads.

However, these designs have inherent limitations when available bone height is less than 10 mm. Thus, close proximity to anatomic structure such as the inferior alveolar canal and maxillary sinus, often hinder the use of conventional length (>10mm) implants. Although some companies offer short implant (≤10mm), these are wide diameter implants (>5mm), which makes their use in narrow ridges impossible.

The other alternative, the use of augmentation procedures, is also far from being ideal. Vertical bone augmentation is still considered not to be a predictable procedure, and whenever augmentation procedures are use, multiple additional factors need to be considered. These include additional fees (sometime doubling the cost of treatment), additional healing time (up to 6 months or more), and of course other adverse effects such as swelling, pain, and discomfort that are commonly associated with bone grafting procedures.

With more and more publications demonstrating the long-term successes of short implants, coupled with the inherent limitations of bone augmentation procedures, short implants are now acceptable as a valid treatment alternative. These successes demonstrate clearly that some of the concepts, including the crown-to-root ratio concept work differently in teeth vs. implants.

Based on current knowledge and understanding of bone biology and implant designs, DenTack aims to present a different solution. The innovative QUAD implant was developed to enable higher primary stability. This is gained by utilizing a unique expandable mechanism, which modifies the implant's geometry after insertion. (Figure 1) This unique pyramidal shape provides load-carrying capabilities, which are equivalent to that of conventional, 10-11.5 mm, implants.
**The QUAD implant**
The QUAD implant was designed with biology in mind. The understanding that bone healing is different in cortical areas than in cancellous areas and with current understanding that undersized osteotomy is beneficial; the QUAD implant utilizes a unique expandable mechanism that affect the cancellous bone only. Post insertion, the apical portion of the implant expands and implant's geometry changes from cylindrical shape to a pyramid shape.

There are significant benefits of this unique morphological change:
1. **Primary stability:** Due to the change in geometry from a cylinder to a square based pyramid, rotational and horizontal stability are increased dramatically.
2. **Force distribution:** like camera’s tripod and many other physical examples, the pyramid shape (post expansion) can handle forces better than cylindrical shapes, and is superior to tapered shapes.
3. **Enlargement of the circumference surface area:** Four titanium membranes, which spread out during implant expansion, enlarge dramatically the contact area with the surrounding bone. (Figure 2)

The result is an implant that compensates for a short length with a morphological change.

**The Mechanism**
The unique mechanism is a "push" mechanism. An internal element moves apically, creating an outwards movement of four wing-shaped elements that create the desired geometrical change. The moving object is self-limiting by design, due to an innovative “snap back” mechanism, and locks upon full expansion. This feature prevents over-expansion or extraction of the moving element out of the body of the implant. As a result, over expansion and over pressure are not possible, and complete control over the procedure is inherent in the mechanism. There were two concerns related to the mechanism: 1) potential damage to bone around the expanded areas; and 2) potential leakage through the mechanism to the apical area surrounding the implant. These issues were addressed in a series of preliminary, bench and animal studies. These demonstrated no mechanical bone damage following expansion, and absolutely no leakage through the mechanism. These results were the background basis for this clinical evaluation, and for achieving the marketing approvals from the European Union.

**Implant placement procedure**
In principle, the only difference between conventional implant placement and the placement of QUAD implants is the expansion stage. Osteotomy is done utilizing straight forward drilling steps: including a marking drill, a pilot drill and widening drills. Expansion is achieved by use of a unique device, which is attached to the implant once it is in its correct position in the bone. (Figure 3) Using torque ratchet set to 35Ncm, the upper component is screwed in, pushing the expansion mechanism of the implant. The device has two clear rings that come into contact when expansion is completed, and used as a secondary safety tool to prevent over-expansion. At this point, the “snap back” mechanism locks. The placement procedure ends when the expansion tool is removed.
Case Series
In order to evaluate the clinical performance of DenTack's QUAD implants, a case series evaluation process was designed. A group of patients who had inadequate bone for conventional implant placement were identified in one clinic (Biodent, Elin-Pelin, Bulgaria). These patients preferred the DenTack implant solution over the alternative options, which included either bridges with no implants, or extensive bone augmentation procedures. These patients gave consent for the use of QUAD implants, and to be evaluated every three to six months following implant placement for a period of up to three years.

The goals: to evaluate the long-term success of QUAD implants in a variety of clinical scenarios, and to evaluate bone health at the expanded area and at the apical area of the implants.

Patient population: Patients were offered treatment with DenTack implants only if an implant was a part of their original treatment plan. Patient population aimed to be random and as diverse as possible, in order to create a very heterogeneous group; males and females, young and old patients, smokers and non-smokers. Exclusion criteria included patients who had specific contraindications for surgery or for implant placement.

Number of patients and implants: One to three implants, in ten to fifteen patients.

Placement protocol: Standard placement procedure into healed bone, adequate for a 7mm QUAD implant: at least 7mm bone height and at least 5mm bone width, or patients requiring simultaneous bone augmentation.

Loading protocol: Implants were loaded after three months of healing.

Restorations: Ceramo-metal restorations.

A summary of the cases

1. **Patients**: Implants were placed in thirteen patients; eight males and five females. Age range was 27-59. Six patients were non-smokers. Some patients smoke more than 20 cigarettes per day.
2. **Implants**: Twenty-three implants were placed. Twenty two of the implants were placed into healed bone. One was placed into an extraction socket.
3. **Data collection**: Accumulated data included bleeding on probing, gingival recession or evident signs of gingival pathology, and radiographs utilizing a Kodak RVG sensor with a Dentsply Rinn Universal Sensor Holder.
4. **Follow-up time**: Follow-up meetings were scheduled 3, 6, 13, 26 and 35 months after implant placement. Twenty implants were followed for 13 months, nineteen were followed for 23-26 months, and eleven were followed for a period of 33-35 months.
5. **Implants survival**: Two of the 23 implants failed within the first 4 months. All other implants are in function and with no evident pathology.

An analysis of the failures reveals that:

a. One implant was restored as a single molar crown. The crown was extremely wide and its occluso-gingival length was larger than that of the implant itself. It functioned as the only posterior support in a patient weighing over 120Kg.

b. The second implant was placed in a patient who is a heavy smoker. The patient wore a temporary denture that placed severe pressure on the area around the implant. Although there was a large sore spot in the area, the patient did not report of any problem and did not contact the clinic for help.
By the time he came for a follow-up visit, the area was heavily inflamed, resulting in a clinical decision to remove the implant.

6. **Bone evaluation:** A qualitative measurement of bone changes around implants was performed by utilizing digital periapical radiographs used with a designated sensor holder, and by using one specific panoramic radiograph machine. The result:
   a. Bone around the expanded area: None of the implants showed bone changes or bone pathology around the expanded area.
   b. Bone around the apical area: None of the implants showed bone changes or bone pathology around the expanded area.
   c. Bone around the neck of implants: no or minor bone loss was observed around implant necks in fifteen of the nineteen surviving implants. In four of the implants a slight bone loss of 1-1.5mm was observed.

7. Restorative phase evaluation: All implants were loaded for at least 3 months prior to final evaluation. No prosthetic complications (such as screw loosening, fractures of porcelain or abutments etc.) were reported.

8. Implant related complications: None of the implants was fractured during expansion or at any point later than that. No other implant related complications were reported.

**Discussion and conclusion**

Available bone height is often the limiting factor when dental implants are considered. In many cases, the posterior areas of both maxilla and mandible have inadequate bone height due to either the maxillary sinus or the mandibular canal. In such cases, if implants are chosen as the restorative option, the clinical alternatives are either to utilize augmentation procedures, or short implants.

Short implants of 6 and 8mm are now considered a standard treatment modality. However, their limited initial stability and wide diameter still prevent them from being used in a large group of people, who have both short and relatively short ridges.

Within the limitation of this case series it can be concluded that no bone changes and no bone pathologies were observed around the expanded areas or around the apex of any one of the QUAD implants that were followed for up to 26 months. Based on that, and on the fact that there were no surgical or prosthetic complications, it can be concluded that:

1. DenTack expanding technology does not cause damage to bone surrounding the expanded area of the implants.
2. Dentack's expanding technology result in a tight seal and no leakage, resulting in no periapical pathologies.
3. DenTack's QUAD expandable implants are a viable solution for a diverse range of clinical scenarios.

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References:


Figures:

Figure 1: The QUAD implant prior and post expansion.

Figure 2: An apical view of the implant. From left to right – a view of the implant at placement, a view of a partly expanded implant and a view of the fully expended implant.

Figure 3: The expansion process.

A: implant in place:

B: Attachment of expansion tool:

C: Use of a torque ratchet at 35Ncm for expansion: