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Effect of the nature and the number of nets on the behavior of dental structures

Y. CHELAHI CHIKR

Laboratory of Mechanical Physical of Materials, Department of Mechanical Engineering, Sidi Bel Abbes University, Algeria

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ABSTRACT

Aim The purpose of this work is to develop a new three-dimensional model of a dental prosthesis.
Methods A dental prosthesis is subjected to one of the three load of mastication (coronoapical, disto-mesial and lingual-oral), applied on the occlusal surface of the crown. The simulation is determined numerically in 3D by the finite element method using the Abaqus calculation code.
Results This numerical analysis allowed us to show the effect of the number of threads and the nature of the thread on the variation of the equivalent stress in the close vicinity of the bone/implant interface. These interfacial constraints are evaluated on the outside and at the bottom of the net. The triangular thread creates more intense stresses than the rectangular and trapezoidal threads on the outside because it has a sharp angle to the outer part.
Conclusion It is important to know the effects of these factors to ensure, on the one hand, the stability and immobility of the dental implant in the alveolar bone and, on the other hand, the mechanical strength of the cortical bone.

KEYWORDS Bone, Implant, Thread, Number of threads, von Mises stress, Interfacial stress, Finite element method.

INTRODUCTION

There are many dental implants and materials used to create restorations such as abutments and crowns. For this reason, different implant geometries have been studied and attempts have been made to modify their shapes in order to improve their biomechanical performance (1), the geometry with stress barrier being one of them. However, the current trend is guided by the development of devices designed to participate in the qualitative and quantitative adjustment of the continuous regeneration of the interfacial bone. Therefore, the future of functional prostheses should take into account the capacity of osseointegration (2).
The objective of this work is to provide a three-dimensional analysis for the geometric configuration of the implant system on the one hand, to study the different types of thread and on the other hand, to define the number of corresponding threads to determine the Von Mises stress placed according to the three direction loads at the bone/implant interface, to know the influence of the stress on the transfer of loads to the bone, which result in implant stability.

METHODS

Different types of threads

A thread is obtained from a cylinder (sometimes from a cone as for the thread of tubes) on which one or more helical grooves have been performed. The remaining full part is called nets. A rod is said to be "threaded" and a hole is "tapped" with regard to the tools that were used historically to produce nets at the beginning of the industrial era. A threaded rod is also called a screw or bolt and a tapped hole nut. In general, in modeling, the threads are executed directly to the tap or die (3).
There are, however, other types of threads, such as square and trapezoidal, for highly specialized sectors (medical, aeronautical, high pressure, optics and photography, and artillery).
In this study, we modeled a dental implant of length (L) 10.43 mm and diameter (D) 5.4 mm with different threads (trapezoidal, rectangular and triangular) and a number of threads equal to 7 (Fig. 1). These nets are made on the surface of the implant to ensure its stability and immobility in the mandibular bone.

RESULTS AND DISCUSSION

Figures 2 to 7 show the variation of the interfacial stress outside and at the bottom of the implant thread under the influence of axial and lateral forces. These constraints are determined at the geometric nodes of the bone structure that are located on the inner and outer contours of the helical thread. These geometric nodes are equidistant and some correspond to stress peaks. These surfaces then constitute very high areas of stress concentration.

Figures 2 and 3 illustrate the variation of interfacial stress respectively outside and at the bottom of the implant thread for vertical loading. It is found that the amplitude of the interfacial stress is almost the same outside and at the bottom of the implant thread and that the triangular threading leads to significant localized stresses at the beginning of the median zone. The intensity of these constraints decreases as one moves away from this area. It is noted that under the effect of the axial forces the two trapezoidal and rectangular threads lead to comparable stress levels but are lower than that of the triangular thread. It is observed that regardless of the type of threading of the dental implant, the interfacial stress outside and at the bottom of the net is almost zero if one moves away from the median zone.

Figures 4 and 5 show the variation of the interfacial stress outside and at the bottom, respectively, of the implant thread under the effect of a lateral load in the disto-mesial direction. The curves of these two figures have the form of a harmonic function with a decreasing amplitude. It should be noted that the rectangular thread generates intense stresses outside the threaded screw. However, the two trapezoidal and triangular threads give rise to stresses of the same intensity and lower than those of the rectangular thread. It is noted

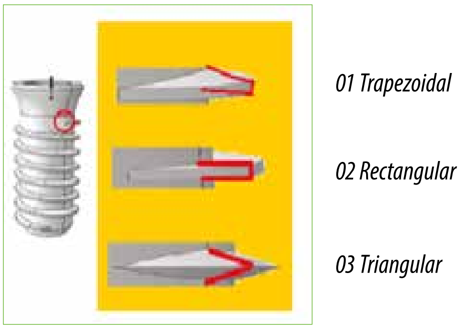

FIG. 1 Implant system components and thread types.

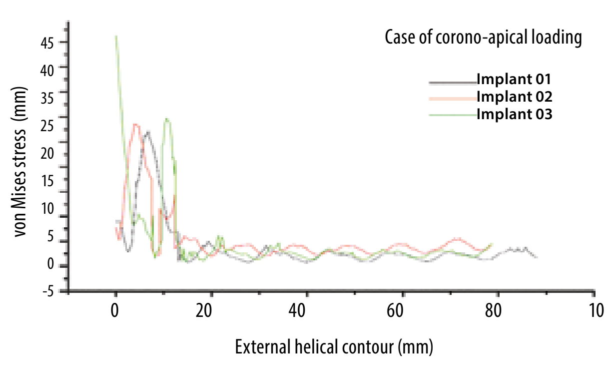

FIG. 2 Variation in interfacial stress outside the implant net depending on the nature of the thread for axial loading.

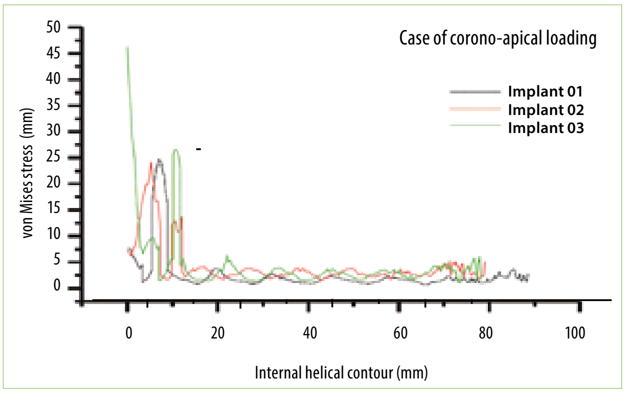

FIG. 3 Variation of interfacial stress at the bottom of the implant net depending on the nature of the thread for axial loading.

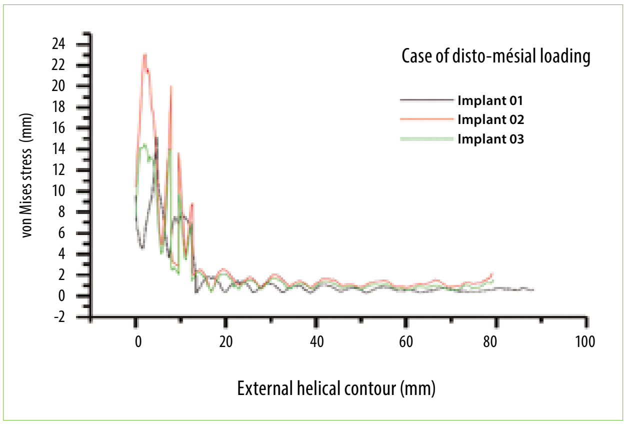

FIG. 4 Variation of the interfacial stress outside the implant thread depending on the nature of the thread for lateral loading.

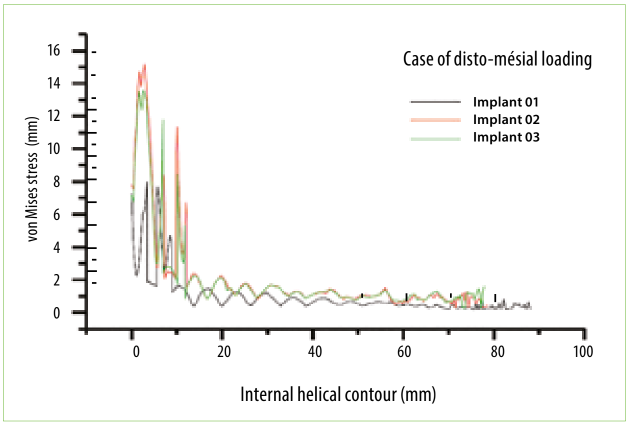

FIG. 5 Variation of the interfacial stress at the bottom of the implant thread depending on the nature of the thread for lateral loading.

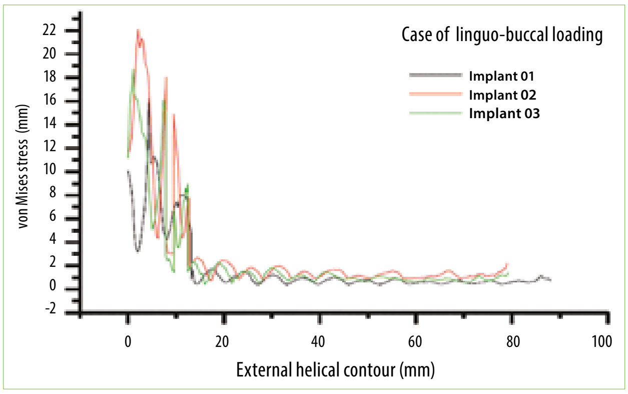

FIG. 6 Interfacial stress variation outside the implant thread depending on the nature of the thread for lateral loading.

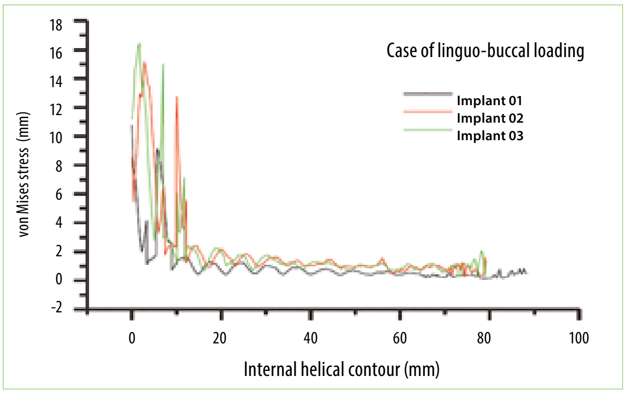

FIG. 7 Variation of the interfacial stress at the bottom of the implant thread depending on the nature of the thread for lateral loading.

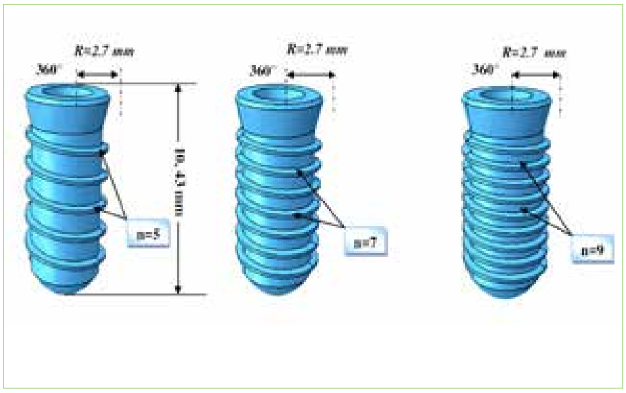

FIG. 8 Geometric model of the dental implant with its dimension.

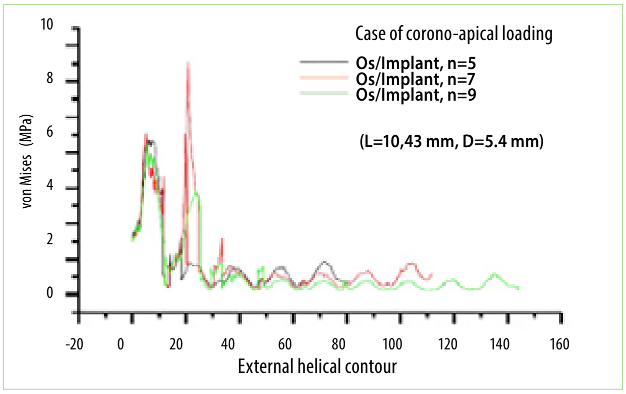

FIG. 9 Variation of interfacial stress outside the implant net depending on the number of nets.

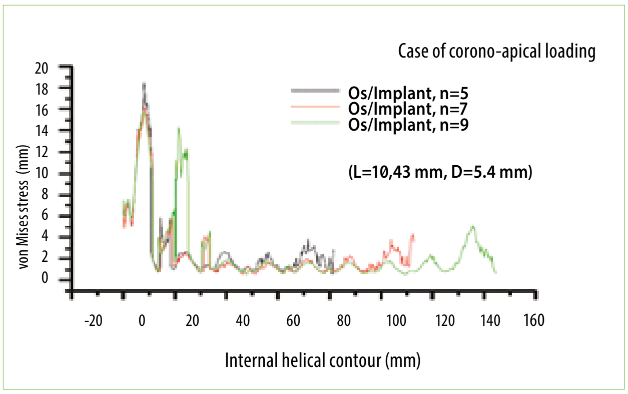

FIG. 10 Variation of interfacial stress outside the implant threads depending on the number of threads.

that at the bottom of the net the level of stress is low compared to that developed outside the thread. It is found that the interfacial stress is almost the same for threads 2 and 3. However, thread 1 leads to constraints of small amplitudes.

The variation of the interfacial stress at the outside and at the bottom of the net under the effect of a lateral load in the linguo-buccal direction is illustrated in figures 6 and 7. Compared with the results found previously, it is found that the lateral disto-mesial and linguo-buccal loads lead to comparable stress levels and this regardless of the type of threading. It is observed that the triangular thread generates more intense stresses than those of the rectangular and trapezoidal threads on the outside because it presents a sharp angle to the outer part of the net. Note that at the bottom of the

Models	Dimensions	
Pillar	L = 08.88 mm, D1 = 02.80 mm, D2 = 03.60 mm	
Implant	L =10.43 mm, D = 5.4 mm	n = 5
		n = 7
		n = 9

TABLE 1 Dimensions of the two elements of the prosthesis.

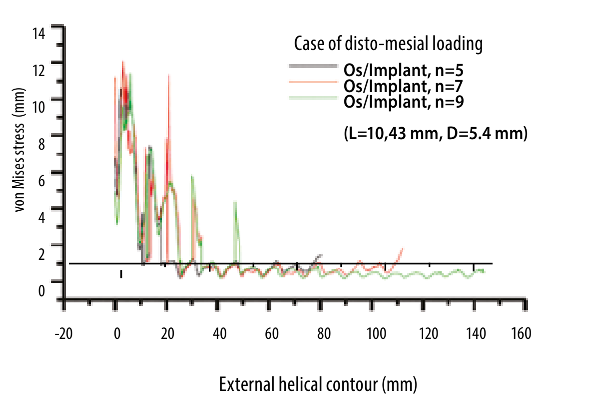

FIG. 11 Variation of the interfacial stress on the outside of the implant net depending on the number of nets.

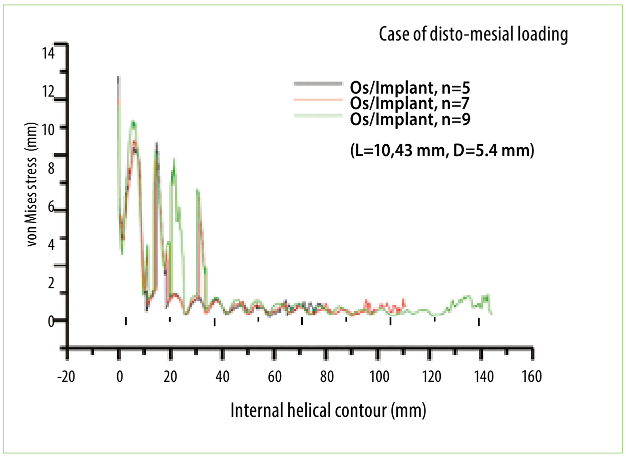

FIG. 12 Variation of the interfacial stress at the bottom of the implant net depending on the number of nets.

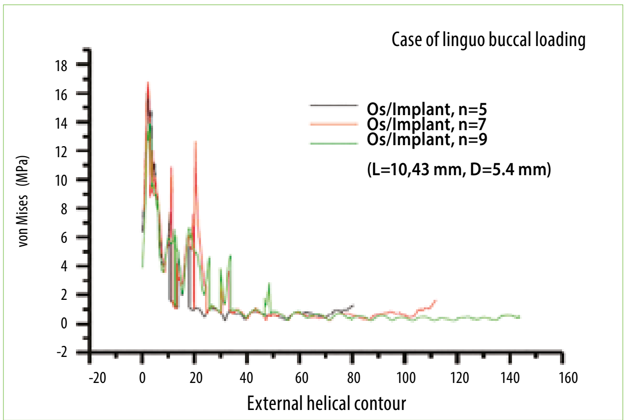

FIG. 13 Variation of the interfacial stress on the outside of the implant net depending on the number of nets.

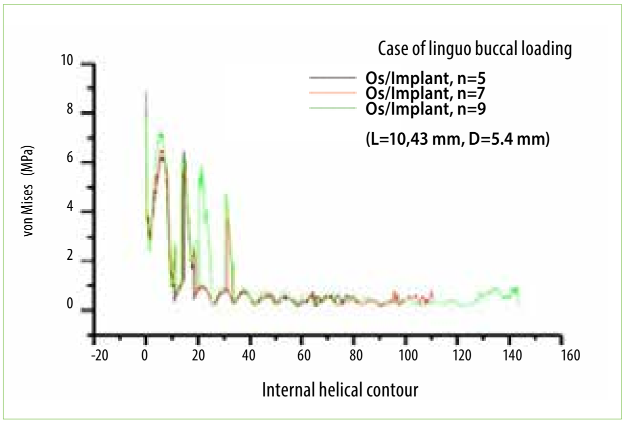

FIG. 14 Variation of the interfacial stress at the bottom of the implant net depending on the number of nets.

net the level of stress is almost identical for the three threads.

On the other hand, we modeled a dental implant of length (L) 10.43 mm and diameter (D) 5.4 mm with trapezoidal threads and a number of threads equal to 5, 7 and 9 (Fig. 8). These nets are made on the surface of the implant to ensure its stability and immobility in the mandibular bone.

The dimensions of the two elements of the dental prosthesis are shown in Table 1:

Figures 9 to 14 illustrate the variation of the equivalent stress at the bottom and outside of the thread of the implant as a function of the number of threads under the influence of the three corono-apical, disto-mesial and linguo-buccal loads.

Figures 9 and 10 represent the variation of the interfacial stress according to the number of nets when the prosthesis is subjected to an axial load following the corono-apical direction. On the outer part of the net it is noted that the curves of the equivalent stress are almost confused at the beginning of the median zone for the three net number. A stress spike for n = 7 and n = 9 is observed at a distance of 20 mm. From the beginning of the thread, this is probably the decrease of the net pitch. At the bottom of the net, it is noted that regardless of the number of nets, the three curves are confused at the beginning of the median zone. A peak of the equivalent constraint is noted for the number of nets equal to nine.

The level of the interfacial stress remains relatively low in the outer part of the net, on the outside and at the bottom of the net respectively, depending the number of nets when the denture is applied to a lateral load following the disto-mesial direction. Two stress spikes are observed, one corresponding to a number of 7 nets on the outside of the net and the other is a number of 5 nets at the bottom of the net. It can be concluded that the dental implant with nine nets leads to a reduction of the stress concentration under the influence of the disto-mesial load.

Figures 13 and 14 show the variation of the interfacial stress, on the outside and at the bottom of the net respectively, as a function of the number of nets when the denture is applied to a lateral load following the linguo-buccal direction. Stress spikes are found on

the outside of the net, corresponding to a number of nets equal to 7 and a peak corresponding to a number of nets equal to 5 at the bottom of the net. It can be concluded that the nine-fillet dental implant leads to a reduction in stress concentration under the influence of linguo-buccal loading.
The results clearly show that the increase in the number of nets influences the variation of the constraint in the vicinity of the OS/implant interface and more especially at the beginning of the middle zone. This effect is due to the decrease in the net pitch, which promotes stress concentrations on the bone/implant contact surface. Increasing the number of nets contributes, on the one hand, to a good mechanical attachment of the implant in the alveolar bone which improves the stability of the osseointegration which leads to an intimate contact between the titanium implant and the living bone tissue and on the other hand, at a stress concentration. This numerical analysis shows that it is necessary to look for an optimal number of nets which ensures a good mechanical coupling and which minimises the concentration of stresses.

CONCLUSION

This analysis allowed to draw the following conclusions. The increase in the number of nets influences the variation of the constraint in the vicinity of the OS/implant interface, especially at the beginning of the median zone. This effect is due to the decrease in the net pitch, which promotes stress concentrations on the bone/implant contact surface. An increase in the number of nets contributes, on the one hand, to a good mechanical attachment of the implant in the alveolar bone, which improves the stability of the osseointegration, which leads to an intimate contact between the titanium implant and the living bone tissue and on the other hand at a stress concentration. This numerical analysis shows us that it is necessary to look for an optimal number of nets which ensures a good mechanical coupling and which minimizes the concentration of stresses.
The triangular thread creates more intense stresses than the rectangular and trapezoidal threads on the outside because it has a sharp angle to the outer part.

REFERENCES

1. Lídia C, Ramos A, Simões A. Finite element analysis of a dental implant system with an elastomeric stress barrier. Summer Bioengineering Conference, June 25–29, Key Biscayne, Florida; 2003.
2. Waters NE. Some mechanical and physical properties of teeth. In: Symposia of the Society for Experimental Biology (The Mechanical Properties of Biological Materials). London: Cambridge University Press; 1980.
3. Threads at rep. Res. PDF. "Taps and Dies Terminology". TapDie.com. Archived from the original on 2006-11-19. Retrieved 2006-12-03 http://www.tapdie.com/html/taps_dies_terminology.html.