Original Article

ACDJ Volume 4, Issue2, April, 2025

One-piece Versus Two-piece Dental Implants

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Abstract:

Aim: it was aimed to estimate the effect of using one piece implant in comparison to two piece one on surrounding bone. ***Methods:*** two three dimensions finite element models were prepared for this study. Standard 3x10mm single piece implant was scanned, and lower first premolar crown was designed, to be placed on it, using ExoCAD. The scanned implant was modified on SoliWorks to be two pieces by adding 1.5mm screw to the abutment part. Bone and mucosa were simplified as three coaxial cylinders, to place the implant in its axis. Lower surface of the cortical bone cylinder was set to be fixed in place as boundary condition. Vertical load of 100N was located at buccal cusp, and distal fossa, and the oblique load of 45° was located at buccal cusp slope, were applied as two loading cases on each model.

Results: the obtained results indicated that one piece implant generated higher stresses on cement layer, and cortical bone in comparison to two pieces implant. On the other hand, crown body above one piece implant received less stresses, by about 5% and 7.5% under vertical and oblique loads respectively, in comparison to two pieces implant.

Conclusions: within limitations of this study derived conclusions were, using two pieces implant might be preferable that it showed less stresses on cement and cortical bone. No wary from implant failure for both implant designs under the applied loads. Crown received less stresses with one piece implant in comparison to two pieces one.

Keywords: Dental implant, one-piece, two-piece, Titanium, Finite element analysis

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Introduction :

The comparison between two piece dental implants and one piece dental implants is affected by their different structural design and procedural characteristics. **(1)**

Since the one piece implant includes the abutment into the same unit, this simplify the procedure and reduce the risk for complications.

While, the two piece implant has separate components which allows more customization which is ideally offering flexibility in complex cases but requires multiple surgical procedures.

In terms of Bone adaptation requirements the one piece implants require optimal bone structure for integration, in contrast, the two piece implants have higher risk of bacterial infiltration and risk of component misalignment. One piece implants were introduced providing the advantage of excluding the microgaps at transmucosal interface. Moreover, for the replacement challenges aspect if damaged, the one piece implant will need the entire unit replacement.**(2.3)** Several studies showed no significant difference between the one and two piece implants in terms of survival rate, marginal bone loss, peri-implant esthetics or prosthetic complications. Proper load distribution should be allowed to be delivered within the physiological tolerance of the supporting tissue which is also affected by the implant-abutment connection.

This study was designed to evaluate the effect of placing one piece implant under lower first premolar crown versus two pieces one on the surrounding bone.**(4)**

Materials and methods:

Two finite element models were created especially for this study, where one piece implant was selected for model #1, and modified by adding 1.5mm diameter screw to its abutment part to simulate two pieces implant in model #2.

That, a standard titanium implant of 3mm in diameter and 10mm in length (by: Dentium, SlimLine, Korea), was coated with an antireflection spray (by: Bilkim, Turkey) and scanned using an optical desktop scanner (by: DS Mizar, Italy) to generate a Standard Tessellation Language (STL) file. On the other hand, crown of lower first premolar was designed using the CAD software ExoCAD (By: exocad GmbH, Germany) with dimensions adjusted to the implant abutments, then its geometry was exported as STL file.

These STL files were used to create the finite element models using ANSYS (ANSYS Workbench version 16.0, USA). Firstly, 3-Matic software (3-Matic version 7.01, Materialise NV, Belgium) was utilized to refine the cloud of points "STL file" and generate outer surfaces of the

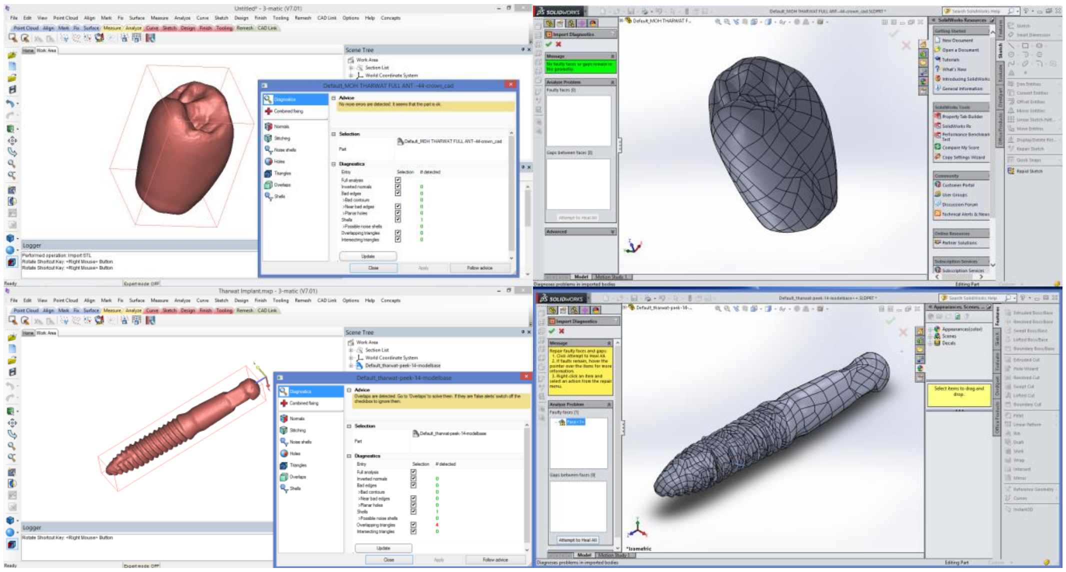

Figure 1: screen shots during transforming STL files to solid parts

scanned bodies, then the surfaces were exported in IGES file format. Secondly, Solidworks (Dassault Systèmes Inc., France) was used to correct / eliminate errors, that found due file format transformation (**Figure 1**).**(5)** Finally these geometries were exported as solid component in STEP file format. The bone geometry was simplified and modeled as two coaxial cylinders representing cancellous (12 mm diameter x 20 mm high) and cortical bone (16 mm diameter x 24 mm high). Boolean operations were performed to create a cement layer of 50µm around the implant, and implant cavity inside the 2mm cylinder simulated the mucosa and simplified bone cylinders.

The second model was created by cutting the implant in the first model into two parts, implant "embedded in bone", and abutment "above implant", then 1.5mm diameter screw was added to the abutment part. The cavity for the screw was created inside the implant body by Boolean operations. The complete models were assembled under ANSYS environment, where materials' properties were assigned to each part of the model as listed in **Table 1**. Each model was meshed, and meshing convergence test was conducted, to ensure result accuracy of each model, where, the final numbers of nodes and elements were listed in **Table 2**. **Figure 2**, demonstrated sample of models components, and final two models.

Table1: Materials properties

	Material	**Young's Modulus**	**Poisson's ratio**
Crown	Zirconia	210,000	0.35
Cement	Resin	8,000	0.30
Abutment	Titanium	110,000	0.33
Implant	Titanium	110,000	0.33
Mucosa		10	0.40
Cortical bone		13,700	0.30
Cancellous bone		1,370	0.30

Table 2: Mesh densities

	Model 1: One Piece		**Model 2: Two Piece**	
	Number of nodes	Number of elements	Number of nodes	Number of elements
Crown	16,149	10,884	16,792	11,376
Cement	2,224	1,091	2,121	1,036
Abutment	-	-	4,856	2,894
Implant	35,699	24,388	29,317	19,740
Mucosa	20,473	13,932	20,473	13,932
Cortical bone	113,824	72,897	113,818	72,903
Cancellous bone	128,856	90,064	125,975	88,008

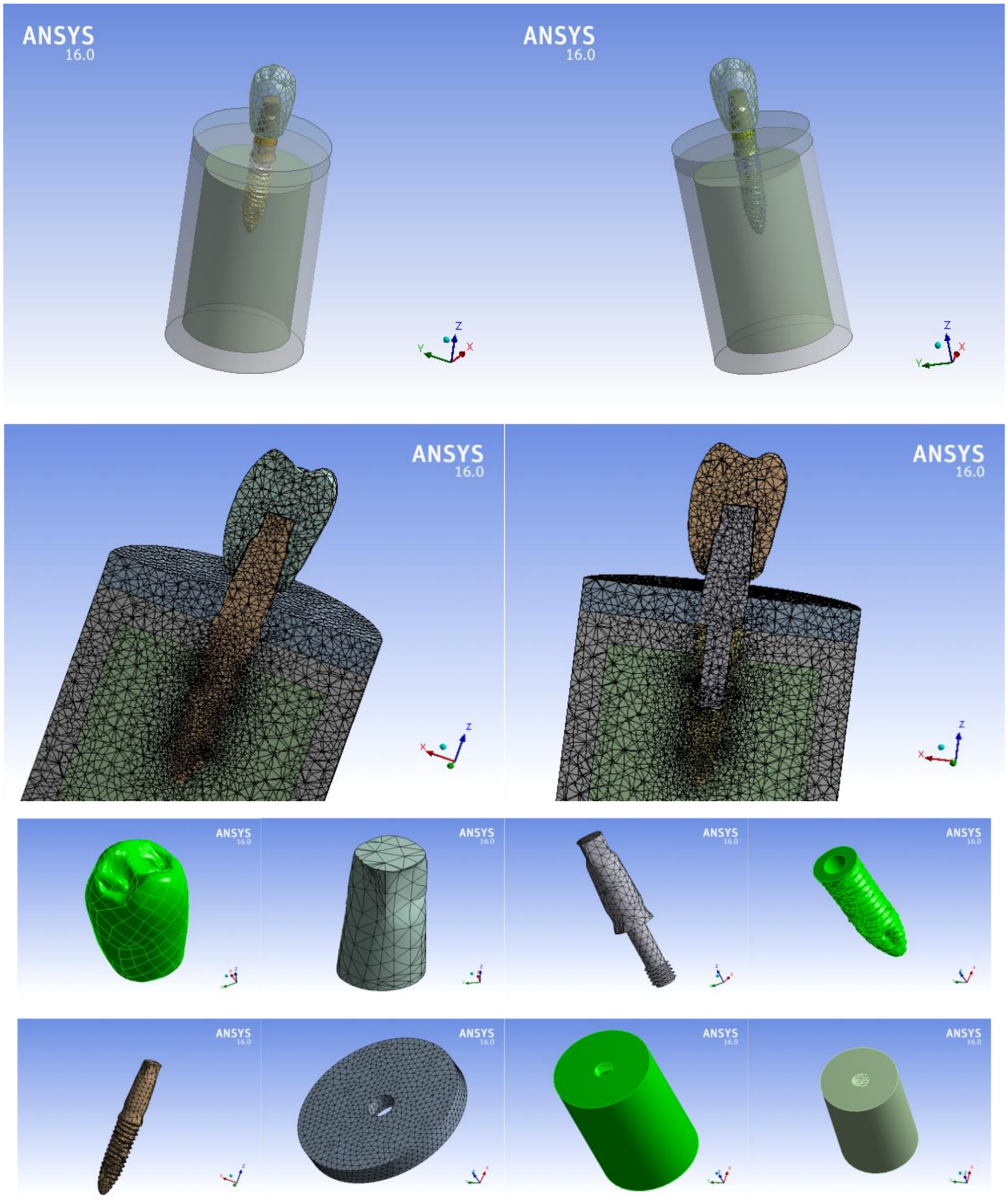

Figure 2: sample of model components and final two models

The results of the created model were verified against similar studies **(6-9)**, before proceeding for extracting results and conclusions. Two loading protocols were examined as; vertical and oblique at 45° to long axis of the implant, with 100 N and 50 N, respectively.**(10)** Vertical load was located at buccal cusp, and distal fossa, while the oblique load was located at buccal cusp slope.**(10)** Lower surface of the cortical bone cylinder was set to be fixed in place as boundary condition. The solid modeling and finite element analysis (linear static analysis) were performed on a Workstation HP Z820, with Dual Intel Xeon E5-2660, 2.2 GHz processors, 64GB
RAM.

Results:

Four linear static analyses were performed within this study. Sample of the obtained deformation and stresses distributions were presented in **Figure 3**, while the comparison between the extreme exerted values were presented in **Figure 4**.

According to deformations and stresses distributions presented to **Figure 3**, the differences in distributions might be negligible, while the values showed considerable differences between vertical and oblique loading cases. On the other hand, comparing behavior between the two implants designs showed negligible deformation differences (less than 1micron). The extreme values of deformations and von Mises stress are presented in **Figure 4** that can lead to recommendation and conclusions.

Mucosa and cancellous bone were insensitive to implant design (one or two pieces) and/or load direction. That means, the load energy will be dissipated in the other components of the model.

One piece implant generated higher stresses on cement layer, and cortical bone in comparison to two pieces implant. These differences ranged between 2.5% and 5% on cement layer under vertical and oblique loading respectively.

Cortical bone showed slightly more stresses with one piece implant by about 2.5%, and 2%, in comparison to the two pieces implant, under vertical and oblique loads respectively. Where, the range of von Mises stress on cortical bone was about 40MPa under vertical load and 75MPa under oblique load is safe and located within physiological limits.

Implant complex body, showed alternating trend, that, <u>one</u> piece implant generated <u>less</u> stresses in comparison to two pieces implant by about 5% under <u>oblique</u> loading. While, the **one** piece implant received von Mises stress reached 129MPa, which is 20% **more** than the two pieces one under **vertical** loads. Crown body above one piece implant received less stresses, by about 5% and 7.5% under vertical and oblique loads respectively, in comparison to two pieces implant.

No wary from failure or fatigue failure by repeating the applied loads that the exerted stresses were far from yielding and fatigue limit of all components.

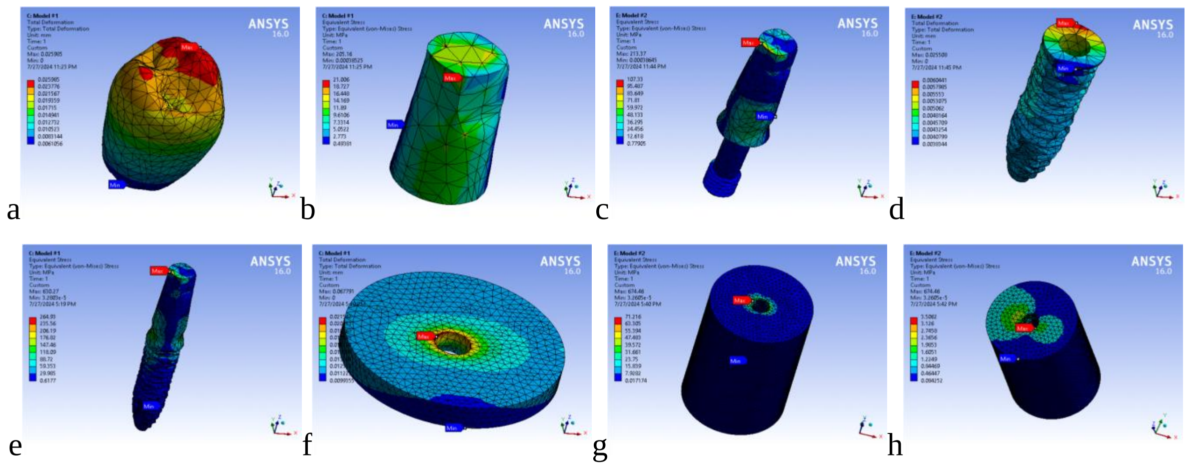

Figure 3: sample of results from the four cases; (a,b) crown and cement layer in model #1 under vertical load, (c,d) implant and abutment in model #2 under vertical load, (e,f) implant and mucosa in model #1 under oblique load, (g,h) cortical and spongy bone in model #2 under oblique load.

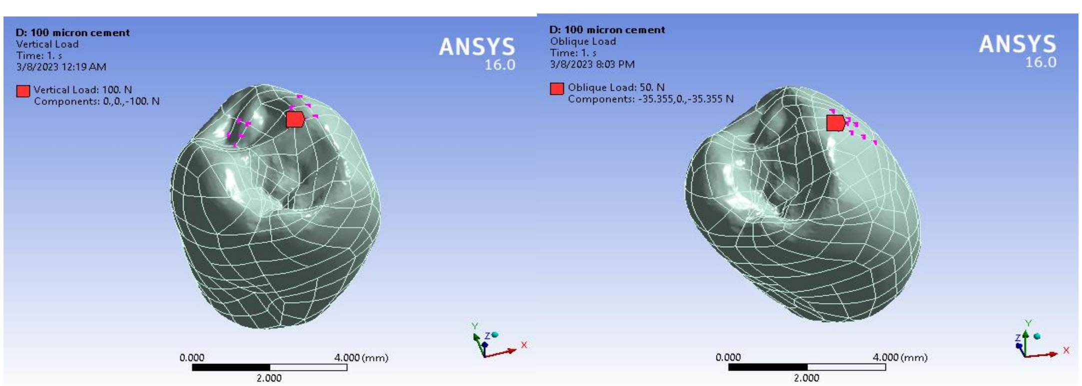

Figure 4: comparison between models results under vertical load and oblique load

Discussions:

Recording of Stresses induced by the one piece dental implant and by the two piece dental implant can be achieved in finite element analysis studies through standardization and variables control as the magnitude, distribution and direction of loads applied were based on previous studies, while yet there’s several limitations**(11)**. The static loading is applied for simplification on the other hand the loading is dynamic during the mastication. Moreover, it was proposed that the dental implants were completely osseointegrated with bone however, this does not simulate the actual situation. Also, the bone has certain properties of a living tissue that is linearly elastic and isotropic, that yet can not be exactly simulated in this study.

One piece implant simplifies the procedure but limits flexibility offered by the two piece implant in adjustments for aesthetics and function. **(12)**

In clinical comparisons, the one piece dental implant did not have a reduced rate of marginal bone loss, so the results of the current study do not suggest more biological and mechanical complications.**(13)**

Mucosa and cancellous bone were insensitive to implant design (one piece or two pieces) in addition to showing very small / negligible changes in stresses and deformation values with load direction change from vertical to oblique.**(14)**

Hajimiragha et al who showed lower stress values induced on the bone of the implant for the one piece dental implant in comparison to the two piece implant, this can be explained in the fact of the strong one body design and the improved mechanical properties of the one piece implant.**(15)**

Two pieces implant may be preferable than one piece implant, that the one piece implant generated slightly higher stresses on cement layer, and cortical bone in comparison to two pieces implant. That may be referred to load energy dissipation in small details like screw and its thread, which help in absorbing more of load energy in implant complex and transferring less energy to underneath structures.**(16)**

On the other hand, both implants showed values of stresses and deformations within physiological limits of bone. Additionally, no failure or cracking in cement layer to be expected under the applied loads. **(13)**

According to studies, two piece implants offer greater flexibility and customization due to their modular design, allowing for adjustments in the abutment selection and placement.

One piece implant body received von Mises stress more than the two pieces one under vertical loads. Contrarily, one piece implant generated less stresses in comparison to two pieces implant oblique loading. That may be referred to considering the screw with small diameter as the weakest point in the implant complex, which may show bad behavior under bending and better one under vertical loading by adding more shear surfaces (thread surface).**(14)**

Being a single piece, the strength of the implant is excellent as there is no separate root portion from an abutment portion. While in two piece implant, there is micro-movement between the implant fixture and the abutment which causes the need for screw retightening at periodic intervals.**(15)**

Crown body above one piece implant received less stresses in comparison to two pieces implant. That, may be a reflect of, using one piece implant design offers slightly better support and less deformations of the crown body.

Conclusions:

Within limitations of this study it can be concluded that, using two pieces implant might be preferable that it showed less stresses on cement layer and cortical bone, that ensures implant stability. No wary from implant failure for both implant designs under the applied loads. Crown body received less stresses with one piece implant in comparison to two pieces one. Therefore, no clear evidence indicating large difference with one of the two designs, so the one and two piece implants can replace each other and function in satisfactory way. Slight better performance might be obtained by the two pieces implants.

ACKNOWLEDGEMENT:

N/A

ETHICAL APPROVAL:

This research does not require ethical approval and followed the Helsinki declaration.

The authors declare that they have no conflict of interest.

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