Article:

Sorrentino, R, Triulzio, C, Tricarico, MG et al. (3 more authors) (2016) In vitro analysis of the fracture resistance of CAD-CAM monolithic zirconia molar crowns with different occlusal thickness. Journal of the Mechanical Behavior of Biomedical Materials, 61. pp. 328-333. ISSN 1751-6161

https://doi.org/10.1016/j.jmbbm.2016.04.014

In vitro analysis of the fracture resistance of CAD-CAM monolithic zirconia molar crowns with different occlusal thickness

INTRODUCTION

Nowadays, all-ceramic crowns represent a viable alternative to metal-ceramic restorations, offering both esthetic and biological advantages: the absence of metal frameworks provides a more natural appearance to restorations and the reduced room necessary to incorporate the prosthesis allows for a more conservative approach to dental tissues and reduced preparation trauma and associated risks (Pjetursson et al. 2007; Land & Hopp 2010; Guess et al. 2011; Wang et al. 2014; Borelli et al. 2015; Ferrari et al. 2015a; Ferrari et al. 2015b; Seydler & Schmitter 2015).

Different materials and fabrication techniques were proposed over the last decade (Della Bona & Kelly 2008; Zarone et al. 2011; Ferrari et al. 2015b). The choice about which ceramic system to use should be made individually for each clinical case, since to date no ceramic material is ideal for all clinical indications (Bindl et al. 2006; Conrad et al. 2007; Rosentritt et al. 2009; Manso et al. 2011; Wang et al. 2014; Ferrari et al. 2015). Independently from the physical and mechanical properties of the materials, damages and fractures mainly occur in posterior regions, where functional loads are higher (Kassem et al. 2010; Land & Hopp 2010; Zarone et al. 2011; Wang et al. 2014; Ferrari et al. 2015a; Ferrari et al. 2015b). Although framework design and firing protocols were optimized, the cohesive fracture (chipping) and delamination of the veneering ceramic is the most common clinical complication, whilst core fracture was reported to be very infrequent (Della Bona & Kelly 2008; Land & Hopp 2010; Guess et al. 2011; Marchack et al. 2011; Zarone et al. 2011; Ferrari et al. 2015a; Ferrari et al. 2015b). Consequently, fabrication strategies and techniques to eliminate the veneering ceramic were developed, till the introduction of Computer Aided Design-Computer Aided Manufacturing (CAD-CAM) monolithic materials, just like zirconia and lithium disilicate (Rojas-Vizcaya 2011; Beuer et al. 2012). Furthermore, monolithic restorations offer the advantages of reduced production times and improved cost-effectiveness (Beuer et al. 2009; Wittneben et al. 2009; Miyazaki & Hotta 2011; Zarone et al. 2011; Wang et al. 2014; Ferrari et al. 2015a; Seydler & Schmitter 2015).

The use of densely sintered Yttria-stabilized Tetragonal Zirconia Polycrystals (Y-TZP) onto both natural teeth and implants became more and more widespread because of its optimal mechanical properties, biocompatibility, esthetics and low wear of the antagonist dentition

(Conrad et al. 2007; Zarone et al. 2011; Mormann et al. 2013; Park et al. 2014; Wang et al. 2014; Ferrari et al. 2015b). Furthermore, the inherent phase transformation toughening mechanism that results in superior fracture resistance seems to limit micro-crack propagation during function (Zarone et al. 2011; Ferrari et al. 2015b).

Although the mechanical properties of zirconia exceed those of many metals, the manufacturers' guidelines suggest a minimum core thickness of 0.5 mm to avoid fractures (Conrad et al. 2007; Zarone et al. 2011; Wang et al. 2014; Ferrari et al. 2014; Ferrari et al. 2015a; Ferrari et al. 2015b; Lan et al. 2015; Nakamura et al. 2015; Nordhal et al. 2015). To date, very few laboratory data about the mechanical predictability of monolithic zirconia crowns are available in the literature, particularly for very thin restorations (Beuer et al. 2009; Choi et al. 2012; Schmitter et al. 2012), as well as the validation of their clinical performances in the oral environment (Sailer et al. 2009; Marchack et al. 2011; Ferrari et al. 2015a). Previous in vitro investigations showed that monolithic zirconia SCs exhibited fracture loads higher than those of layered zirconia restorations (Dhima et al. 2013; Sun et al. 2014; Lan et al. 2015). Recently, an in vitro analysis reported that monolithic zirconia crowns with an occlusal thickness of 0.5 mm showed sufficient fracture resistance to withstand occlusal loads in the molar regions (Nakamura et al. 2015). Nonetheless, a minimum recommended thickness for monolithic zirconia SCs validated by scientific data has not been established yet and there is no consensus on how thin the crowns can be made. Moreover, data are lacking on to what extent the reduced thickness of monolithic Y-TZP copings affect the fracture strength. Consequently, it is paramount to prove a minimum thickness to guarantee the load bearing capacity of the restorations under occlusal loads (Lan et al. 2015).

The present in vitro study aimed at comparing the fracture resistance and mode of failure of CAD-CAM monolithic zirconia single crowns (SCs) with different occlusal thickness cemented onto human molars.

The null hypotheses stated that there was no association between the occlusal thickness and either the fracture resistance [1] and the mode of failure [2] of CAD-CAM monolithic zirconia SCs.

MATERIALS AND METHODS

Forty extracted human maxillary third molars were used for the study. Teeth with caries and/or previous restorations were excluded; only sound teeth with similar (±1 mm) (Salameh et al. 2007) bucco-lingual, mesio-distal and corono-apical dimensions were

included in the study. Dental plaque, calculus and external debris were removed with an ultrasonic scaler. In order to simulate the oral environment, the teeth were stored in an incubator at 37°C in 90% relative humidity until the execution of the mechanical tests.
Each tooth was embedded in a block of self-curing acrylic resin (Caulk Orthodontic Resin, Dentsply caulk, Milford, DE, USA) surrounded by a stainless steel cylinder with the long axis perpendicular to the base of the block, leaving 1 mm of the root exposed. In order to dissipate the heat generated during the polymerization of the resin, the specimens were continuously moistened with water spray. A thin layer of polyvinylsiloxane impression material (Flexitime, Heraeus Kulzer, Hanau, germany) was applied on dental roots to simulate the periodontal ligament (Sorrentino et al. 2007).
Each tooth was covered with a powder for digital scanning (Cerec Optispray, Sirona Dental, Salzburg, Austria) and three-dimensionally (3D) scanned by means of a laboratory optical digital scanner (GC Aadva Lab Scan, GC, Tokyo, Japan). The 3D shape of each tooth was digitized, so as to use it for the fabrication of CAD-CAM monolithic crowns.
Standardized tooth preparations were performed with high-speed diamond rotary cutting burs under constant water cooling, according to the following geometry: 1 mm axial reduction, 0.7 peripheral rounded minichamfer shoulder placed 0.5 mm above the cemento-enamel junction, 12° of total occlusal convergence; all preparation angles were rounded. The 40 molars were randomly divided into 4 groups of 10 specimens each and different occlusal thickness preparation were performed as follows: 2.0 mm (group 1), 1.5 mm (group 2), 1.0 mm (group 3) and 0.5 mm (group 4).
As previously described, each abutment tooth was scanned and digitized and 40 monolithic zirconia SCs were designed by means of a dedicated CAD software (Exocad DentalCAD, Exocad GmbH, Darmstadt, Germany) according to the original shape of each tooth. The monolithic zirconia restorations of group 1, 2, 3 and 4 presented with an occlusal thickness of 2.0, 1.5, 1.0 and 0.5 mm respectively. A cement layer of 70 μm and 50 μm was simulated at level of the intaglio surface and of the minichamfer shoulder respectively.
The internal surface of each crown was sandblasted with 50 μm Al_2O_3 powder at 1 bar. The SCs were cleaned with steam for 60 sec. A dual-cure self-adhesive universal resin cement (G-Cem LinkAce, GC, Tokyo, Japan) was used to lute the restorations. The crowns were seated onto the abutment teeth with finger pressure and then 5 kilograms were applied onto each crown for 5 min by means of a dedicated cementation appliance. Cement excess was removed with a microbrush and each surface was light-cured for 40 sec with a LED curing unit (Elipar S10, 3M ESPE, Seefeld, Germany). A layer of glycerin

gel was applied on the margin of each crown to block oxygen inhibition and polymerization was completed for 40 sec on each surface.

A universal loading machine (Triaxial Tester T400 Digital, Controls srl, Cernusco, Italy) was used to statically load the specimens. Load to fracture was performed using a 1.0 mm stainless steel hemispherical tip placed in the occlusal fossa. The experimental load was applied at a crosshead speed of 1 mm/min in a direction parallel to the longitudinal axis of the tooth. All samples were loaded until fracture and the maximum breaking loads were recorded in Newtons (N) by a computer (Digimax Plus, Controls srl, Cernusco, Italy) connected to the loading machine. The failure mode was visually evaluated using a stereomicroscope at 10x magnification (Zeiss OpMi1, Zeiss, Oberkochen, Germany); and in case of fracture, the fracture pattern was examined using a scanning electron microscope (Jeol, Tokyo, Japan).

The recorded data were statistically analyzed with a dedicated software (SPSS 13.0, SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to verify the normality of data distribution. The fracture values were analyzed with the one-way ANOVA followed by the Kruskal-Wallis on ranks test for multiple comparisons. For all the statistical tests, the level of significance was set at $p=0.05$.

RESULTS

The highest fracture resistance values were reported in group 1 while the lowest were noticed in group 4 (Table 1).

All the crowns showed cohesive microcracks of the zirconia core in the occlusal region, particularly at level of the load application area; only 1 crown in group 4 was interested by a complete fracture.

No statistically significant differences between groups were evidenced either for the fracture strength ($p>0.05$) and the failure mode ($p>0.05$) (Table 2).

DISCUSSION

The present in vitro study analyzed the fracture resistance and mode of failure of molar CAD-CAM monolithic zirconia SCs with occlusal thicknesses ranging between 0.5 and 2.0 mm. According to the results of the present investigation, both the null hypotheses were accepted, since there were no statistically significant differences in the fracture resistance

[1] and mode of failure [2] of CAD-CAM monolithic zirconia SCs in relation to the occlusal thickness.
In the present study, the survival rate of molar CAD-CAM monolithic zirconia SCs was 100% in the experimental groups 1, 2 and 3 and 90% in group 4. Only 1 crown in group 4 showed a complete core failure, while all the other specimens showed cohesive microcracks of the occlusal surfaces at level of the load application area. From a clinical viewpoint, the cohesive occlusal microcracks have to be considered repairable, since they could be polished intraorally without impairing function.
Although the CAD step of the production requires time and expertise of the operator, the fabrication of monolithic crowns is less complex and time-consuming than that of conventional veneered restorations, since the layering and firing procedures are eliminated at all (Seydler & Schmitter 2015). Moreover, the purely CAD-CAM fabrication allows to keep files over time, making it possible to produce identical crowns if necessary, such as in case of clinical complications or failures (Ferrari et al. 2015b).
The geometry and thickness of all-ceramic crowns influence the fracture strength of restorations (Ferrari et al. 2014; Sun et al. 2014). Although most investigations reported that thicker zirconia copings showed higher fracture strength (Kim et al. 2012) and doubling the monolithic zirconia core from 0.6 to 1.5 mm increased the fracture resistance of the restorative system threefold (Sun et al. 2014), a recent in vitro analysis demonstrated that an occlusal thickness of 0.5 mm allowed monolithic zirconia crowns to withstand occlusal forces in the molar areas (Nakamura et al. 2015).
Several studies reported higher flexural strength of monolithic to veneered zirconia (Zhang et al. 2013; Sun et al. 2014). Veneering ceramic represents the weak link of all kinds of prosthetic crowns; moreover, monolithic restorations fabricated by CAD-CAM techniques exhibited less flaws than manual or heat pressing veneered crowns (Sun et al. 2014).
Load to fracture was applied using a 1.0 mm stainless steel hemispherical tip, so as to fit in the fossae of anatomically shaped crowns (Yoshinari & Derand 1994; Nordhal et al 2015).
The recorded fracture values of all the experimental groups exceeded both the physiological (50-250 N) and parafunctional (500-900 N) occlusal loads in molar regions (Kampe, 1987; Kiliaridis et al. 1993; Waltimo & Kononen, 1995; Ferrario et al., 2004); thus, monolithic zirconia crowns showed sufficient fracture strength and stiffness for use in posterior areas (Seydler & Schmitter 2015). In accordance with previous investigations (Nordhal et al. 2015), the results of the present analysis suggested the possibility to reduce crown thickness when fabricating monolithic Y-TZP crowns, reducing the

invasiveness of the preparation and saving a valuable amount of dental tissues (Nordhal et al. 2015). However, it is not possible to apply laboratory information directly to clinical recommendations, since the clinical scenario is never completely simulated in in vitro tests (Anusavice et al. 2007). As a consequence, the results of the present investigation have to be validated clinically since only a static perpendicular force was simulated.

In the present investigation, it was decided to lute the monolithic zirconia crowns onto natural teeth to simulate a real clinical situation, shaping the zirconia cores anatomically and performing correct adhesive cementation procedures; the use of metal samples with standardized geometry would act as a confounder in relation to the conditions of the oral environment.

Although the increase in fracture resistance of zirconia by means of adhesive cementation was never clearly demonstrated and the use of conventional cements is a valid option (Vult von Steyern et al. 2006; Bindl et al. 2006; Rosentritt et al. 2009; Manso et al. 2011;), in this study the monolithic zirconia crowns were luted with a dual-cure self-adhesive universal resin cement. This choice was due to the simplification of cementation procedures allowed by self-adhesive resin cements; the self-cure mode ensures optimal polymerization and the phosphate monomers contained in these cements were proved to guarantee a valid bonding durability both to enamel and dentin and to zirconia surface (Magne et al. 2015).

It was reported that adhesive bonding significantly increased fracture strength and improved marginal seal of all-ceramic crowns (Blatz et al. 2008; Borges et al. 2009; Lu et al. 2013; Kern 2015). Furthermore, restorative adhesive complexes should form a "monoblock" to ensure long-lasting restorations (Schwartz & Robbins, 2004; Tay & Pashley, 2007). It can be speculated that the above reported characteristics of the self-adhesive resin cement in combination with careful luting procedures could enable the formation of such an adhesive monoblock, letting the cement act as an elastic stress adsorber and compensating for the stiffness of the zirconia core. This could strengthen the restorative system, allowing to dissipate the occlusal loads on the entire intaglio surface of the crowns.

CONCLUSIONS

Within the limitations of the present in vitro study, the following conclusions can be drawn:

- the occlusal thickness of CAD-CAM monolithic zirconia crowns did not influence either the fracture resistance and the mode of failure of the restorations;

- the occlusal thickness of CAD-CAM monolithic zirconia crowns can be reduced up to a lower bound of 0.5 mm keeping a sufficient strength to withstand occlusal loads;
- CAD-CAM monolithic zirconia crowns showed sufficient fracture resistance to be used in molar regions, even in a thin configuration (0.5 mm).

Further clinical investigations will be necessary to validate the results of the present study under functional loading.

REFERENCES

Anusavice KJ, Kakar K, Ferree N. Which mechanical and physical testing methods are relevant for predicting the clinical performance of ceramic-based dental prostheses? Clin Oral Implants Res, 2007;18:218-231.

Beuer F, Schweiger J, Eichberger M, Kappert HF, Gernet W, Edelhoff D. High-strength CAD/CAM-fabricated veneering material sintered to zirconia copingsea new fabrication mode for all-ceramic restorations. Dent Mater 2009;25:121-128.

Beuer F, Stimmelmayr M, Gueth JF, Edelhoff D, Naumann M. In vitro performance of full-contour zirconia single crowns. Dent Mater 2012;28: 449-456.

Bindl A, Lüthy H, Mörmann WH. Strength and fracture pattern of monolithic CAD/CAM-generated posterior crowns. Dent Mater 2006;22:29-36.

Borelli B, Sorrentino R, Goracci C, Amato M, Zarone F, Ferrari M. Evaluating residual dentin thickness following various mandibular anterior tooth preparations for zirconia full-coverage single crowns: an in vitro analysis. Int J Periodontics Restorative Dent, 2015;35:41-47.

Borges GA, Caldas D, Taskonak B, Yan J, Sobrinho LC, de Oliveira WJ. Fracture loads of all-ceramic crowns under wet and dry fatigue conditions. J Prosthodont 2009;18:649-655.

Choi YS, Kim SH, Lee JB, Han JS, Yeo IS. In vitro evaluation of fracture strength of zirconia restoration veneered with various ceramic materials. J Adv Prosthodont 2012;4:162-169.

Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review. J Prosthet Dent 2007;98:389-404.

Della Bona A, Kelly JR. The clinical success of all-ceramic restorations. J Am Dent Assoc 2008;139(suppl):8S-13S.

Dhima M, Assad DA, Volz JE, An KN, Berglund LJ, Carr AB, Salinas TJ. Evaluation of fracture resistance in aqueous environment of four restorative systems for posterior applications. J Prosthodont, 2013;22:256-260.

Ferrari M, Giovannetti A, Carrabba M, Bonadeo G, Rengo C, Monticelli F, Vichi A. Fracture resistance of three porcelain-layered CAD/CAM zirconia frame designs. Dent Mater, 2014;30:e163-e168.

Ferrari M, Sorrentino R, Cagidiaco C, Goracci C, Vichi A, Gherlone E, Zarone F. Short-term clinical performance of zirconia single crowns with different framework designs: 3-year clinical trial. Am J Dent, 2015a;28:235-240.

Ferrari M, Vichi A, Zarone F. Zirconia abutments and restorations: from laboratory to clinical investigations. Dent Mater, 2015b;31:e63-e76.

Ferrario VF, Sforza C, Zanotti G, Tartaglia GM. Maximal bite forces in healthy young adults as predicted by surface electromyography. J Dent, 2004;32:451-457.

Guess PC, Schultheis S, Bonfante EA, Coelho PG, Ferencz JL, Silva NR. Allceramic systems: Laboratory and clinical performance. Dent Clin North Am 2011;55:333-352.

Kampe T. Function and dysfunction of the masticatory system in individuals with intact and restored dentitions. A clinical, psychological and physiological study. Swed Dent J Suppl 1987;42:1-68.

Kassem AS, Atta O, El-Mowafy O. Survival rates of porcelain molar crownsan update. Int J Prosthodont 2010;23:60-62.

Kern M. Bonding to oxide-ceramics - laboratory testing versus clinical outcome. Dent Mater, 2015;31:8-14.

Kiliaridis S, Kjellberg H, Wenneberg B, Engstrom C. The relationship between maximal bite force, bite force endurance, and facial morphology during growth. A cross-sectional study. Acta Odontol Scand 1993;51:323-331.

Lan TH, Liu PH, Chou MM, Lee HE. Fracture resistance of monolithic zirconia crowns with different occlusal thicknesses in implant prostheses. J Prosthet Dent, 2015 Sep 24;doi: 10.1016/j.prosdent.2015.06.021 [Epub ahead of print].

Land MF, Hopp CD. Survival rates of all-ceramic systems differ by clinical indication and fabrication method. J Evid Based Dent Pract 2010;10:37-38.

Lu C, Wang R, Mao S, Arola D, Zhang D. Reduction of load-bearing capacity of all-ceramic crowns due to cement aging. J Mech Behav Biomed Mater 2013;17:56-65.

Magne P, Carvalho AO, Bruzi G, Giannini M. Fatigue resistance of ultrathin CAD/CAM complete crowns with a simplified cementation process. J Prosthet Dent, 2015;114:574-579.

Manso AP, Silva NR, Bonfante EA, Pegoraro TA, Dias RA, Carvalho RM. Cements and adhesives for all-ceramic restorations. Dent Clin North Am 2011;55:311-332.

Marchack BW, Sato S, Marchack CB, White SN. Complete and partial contour zirconia designs for crowns and fixed dental prostheses: a clinical report. J Prosthet Dent, 2011;106:145-152.

Miyazaki T, Hotta Y. CAD/CAM systems available for the fabrication of crown and bridge restorations. Aust Dent J 2011;56(suppl 1):97-106.

Mormann WH, Stawarczyk B, Ender A, Sener B, Attin T, Mehl A. Wear characteristics of current aesthetic dental restorative CAD/CAM materials: two-body wear, gloss retention, roughness and martens hardness. J Mech Behav Biomed Mater 2013;20:113-125.

Nakamura K, Harada A, Inagaki R, Kanno T, Niwano Y, Milleding P, Örtengren U. Fracture resistance of monolithic zirconia molar crowns with reduced thickness. Acta Odontol Scand, 2015;73:602-608.

Nordhal N, Vult von Steyern P, Larsson C. Fracture strength of ceramic monolithic crown systems of different thickness. J Oral Sci, 2015;57:255-261.

Park JH, Park S, Lee K, Yun KD, Lim HP. Antagonist wear of three CAD/CAM anatomic contour zirconia ceramics. J Prosthet Dent 2014;111:20-29.

Pjetursson BE, Sailer I, Zwahlen M, Hämmerle CH. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part I: Single crowns. Clin Oral Implants Res 2007;18(suppl 3):73-85.

Rojas-Vizcaya F. Full zirconia fixed detachable implant-retained restorations manufactured from monolithic zirconia: clinical report after two years in service. J Prosthodont 2011;20:570-576.

Rosentritt M, Behr M, Thaller C, Rudolph H, Feilzer A. Fracture performance of computer-aided manufactured zirconia and alloy crowns. Quintessence Int 2009;40:655-662.

Sailer I, Gottnerb J, Kanelb S, Hammerle CH. Randomized controlled clinical trial of zirconia-ceramic and metal-ceramic posterior fixed dental prostheses: a 3-year follow-up. Int J Prosthodont, 2009;22:553-560.

Schmitter M, Mueller D, Rues S. Chipping behaviour of all-ceramic crowns with zirconia framework and CAD/CAM manufactured veneer. J Dent 2012;40:154-162.

Seydler B & Schmitter M. Clinical performance of two different CAD/CAM-fabricated ceramic crowns: 2-year results. J Prosthet Dent, 2015;114:212-216.

Sun T, Zhou S, Lai R, Liu R, Ma S, Zhou Z, Longquan S. Load-bearing capacity and the recommended thickness of dental monolithic zirconia single crowns. J Mech Behav Biomed Mater, 2014;35:93-101.

Vult von Steyern P, Ebbesson S, Holmgren J, Haag P, Nilner K. Fracture strength of two oxide ceramic crown systems after cyclic pre-loading and thermocycling. J Oral rehabil, 2006;33:682-689.

Waltimo A, Kononen M. Maximal bite force and its association with signs and symptoms of craniomandibular disorders in young Finnish non-patients. Acta Odontol Scand, 1995;53:254-258.

Wang X, Fan D, Swain MV, Zhao K. A systematic review of ceramic crowns: clinical fracture rates in relation to restored tooth type. Int J Prosthodont 2012;25:441-450.

Wittneben JG, Wright RF, Weber HP, Gallucci GO. A systematic review of the clinical performance of CAD/CAM single-tooth restorations. Int J Prosthodont 2009;22:466-471.

Yoshinari M, Derand T. Fracture strength of all-ceramic crowns. Int J Prosthodont, 1994;7:329-338.

Zarone F, Russo S, Sorrentino R. From porcelain-fused-to-metal to zirconia: clinical and experimental considerations. Dent Mater, 2011;27:83-96.

n	GROUP 1 (2.0 mm)		GROUP 2 (1.5 mm)		GROUP 3 (1.0 mm)		GROUP 4 (0.5 mm)	
	Fracture load (N)	Failure mode	Fracture load (N)	Failure mode	Fracture load (N)	Failure mode	Fracture load (N)	Failure mode
1	1602.24	R	1818.98	R	1870.88	R	1866.13	R
2	1719.21	R	1769.56	R	1163.83	R	2140.31	R
3	1621.09	R	1391.32	R	1322.59	R	747.54	U
4	1720.40	R	1737.85	R	1974.43	R	1647.95	R
5	1644.12	R	691.30	R	2048.64	R	2156.06	R
6	1791.61	R	1206.91	R	1352.07	R	1353.16	R
7	1732.58	R	1872.28	R	1603.73	R	1489.45	R
8	1735.17	R	1668.44	R	2020.96	R	1424.63	R
9	1693.02	R	1773.74	R	1596.61	R	956.33	R
10	1603.68	R	1609.99	R	1595.63	R	1355.59	R

Table 1 - Load at fracture (in Newtons) and failure patterns (R: restorable, U: unrestorable) of the experimental specimens.

GROUP	n	Fracture resistance (N/mm^2)		Sig.
		Mean	SD	
1	10	1686.31	±64.84	A
2	10	1554.04	±366.28	A
3	10	1654.94	±314.57	A
4	10	1513.71	±460.01	A

Table 2 - Mean fracture load values (in Newtons) ± Standard Deviations of the experimental specimens and statistical significance (Sig.).