TASK 1: WHAT ARE THE MATERIALS AND METHODS OF THE CURRENT RESEARCH?
TASK 2: TAKE 5 TERMS OUT OF THE ARTICLE AND GIVE SHORT EHPLANATION TO EACH ONE OF THEM - PROSTHETIC STRUCTURE, ABUTMENT SCREW, FRACTURE, ETC.

Bio-mechanical factors related to the fracturing dental implants

Introduction

In recent years the use of dental implants in the treatment of partial or complete edentulism has been considered as a routine method with a high success rate. Along with the growing number of cases of implant prosthetics, the likelihood of complications associated with this treatment method increases. The loss of osseo-integrated implant can be caused both by secondary infections and peri-implantitis and some bio-mechanical complications as loosening and fracture of the abutment screw or fracturing the body of the implant.

The studies conducted up to now indicate that the fracture of implants is observed relatively rare with an estimated incidence of 0.2 to 1.5 %. However, the clinical effect to the patient and clinician are serious due to concurrent loss of both the implant and prosthetic structure. The factors leading to this serious complication are numerous and of different nature and can be grouped into two main groups.

The first group is associated with biomechanical and physiological overload and includes parafunctions and prosthetic design. Parafunctional activity in clenching as well as in bruxism can generate a much higher load over the prosthesis and implants. Some features in prosthetic design as a cantilever and non-balanced occlusion as well, are also associated with occlusal overload due to generating forces with unwanted size and direction.Various studies highlight the shortcomings of the cantilever extensions and focus on precise alignment of occlusal contacts as a way to preventlate complications.

The second group is associated with bio-mechanical planning structures, available bone volume, implant area, diameter and number of implants, their inclination to the sagittal

and transverse planes. According to some studies the implants with a diameter of 3.75 mm or smaller have a greater tendency to break compared to those with a larger diameter. The scientific analyses indicate that a higher incidence of this complication is established in the area of molars and premolars.This is due to the higher values of masticatory pressure in these zones during the masticatory act. According to the studies of Gargalo-Albiol J et al. the onset of these complications is during the first 2-3 years after the implants start functioning. Other studies point out that the likelihood of fracture of the implant components rises over time due to material fatigue caused by increased occlusal load.

Aim of the study:

To establish the reasons for fracturing the implant supports, the size of the effect and connections between them.

Material and methods:

101 patients treated by us with 218 dental implants have been analysed during the period from 2006 to 2016. When choosing locations for implantation a prosthetic oriented approach was applied, complying with the parameters of the boneavailable.The used diameters ranged from 3.2 mm to 6.0 mm in accordance with the recommended dimensions for the respective zones. The implantation was performed as an open surgical procedure, strictly following the manufacturers' surgical protocols.The following implant systems were used: TBR Connect®, Z1-Connect®, Periosave® M and Z1-M (TBR Implants Group - France), Ankylos® (Dentsply Implants - Germany) and Straumann® Bone Level implants (Straumann - Switzerland). All recreational structures were still and made after a standard period for osseointegration – six months for the maxilla and four months for the mandibula.

The anatomical features in the areas of implantation were tested: available bone volume, location (upper molars, upper premolars, upper front teeth, lower molars and lower front teeth) as well as the characteristics of the final implant positions – mesio-distal and vestibulo-lingual inclination. The type of recreational structures was analysed (single crowns, splinted crowns, bridge "implant – implant" and bridge "implant - natural teeth"), the type of connection between implant and abutment (internal octagon or conical connection) and the size of used diameters. Functionally it was recorded the presence of biomechanical and physiological overload, including parafunctions, availability of cantilever and non-balanced occlusion, insufficient number and incorrectly selected positions of dental implants. The following complications were reported: degree of crestal resorption, loosening and fracture of the abutment screws, fracturing implant supports, as well as the time of setting-in.

The statistical processing of results was performed by means of IBM SPSS Statistics 20 (IBM - USA). The following descriptive assessment methods were applied - variational analysis of quantitative variables and frequency analysis of qualitative variables (nominal and ranked), which includes absolute and relative frequencies.

In order to investigate the relationship between the fracturing dental implants and other tracked anatomical, functional and technological factors the rank correlation coefficient Spearman Rho was used.

Kruskal-Wallis' test was intentionally applied to verify the hypothesis that the type of prosthetic structure, parafunctions, non-balanced occlusion, marginal bone loss, screw-loosening and time of complications set in do not affect the cases with fracturing dental implants. For each of the groups in pairs post hoc Mann-Whitney test was made with regard to determine accurately the impact of the factor influencing the track-out indicator. The tests

were reported by means of Bonferroni correction coefficient for the size of the effect upon the track-out factor (Bonferroni corrected post hoc Mann-Whitney test).

Results:

The results are based on 101 monitored patients with 218 fitted implants and a follow-up period of 3 to 10 years. 46 (45.54%) of them are females and 55 (54.46%) are males. In women we used 73 implants (33.49%) while in men - 145 (66.51%). The distribution regarding the areas of implantation is as follows: upper molars - 20 (9.2%), upper premolars - 38 (17.4%), upper front teeth - 36 (16.5%), lower molars - 77 (35.3%), lower premolars - 23 (10.6%) and lower front teeth - 24 (11.0%). Depending on the type of restorative structure, the distribution is as follows: single crowns - 99 (45.4%), splinted crowns - 21 (9.6%), bridge "implant - implant" - 56 (25.7%) and bridge "implant - natural teeth "- 42 (19.3%). Cantilever was established in 30 implants (13.76%), 26 (11.93%) of which were with up to 3 mm and 4 (1.83%) with up to 5 mm. The rest 188 cases (86.24%) are cantilevered without binding. Parafunctional activity was found out in patients with a total of 17 implants and non-balanced occlusal-articulatory ratios in prosthetic structures on 22 implants.

These complications were established while tracking the following cases: marginal bone loss - from 1.0 to 3.0 mm in 52 cases (23.9%); between 4.0 and 6.0 mm in 18 cases (8.3%); screw-loosening - 17 cases (7.8%); fracture of the screw [19] - 4 cases (1.8%); fracturing the implant - 5 cases (2.3%).

The frequency distribution of the majority of track-out indicators showed that their values are not normally distributed, which imposed the use of non-parametric methods for carrying out the statistical analysis.

When examining the correlation coefficient "Rho" using Spearman's test (SpearmanRho) a statistically significant correlation was found in cases of fracturing the dental implant and the impact of the following factors: parafunctions, non-balanced occlusion and errors in planning the prosthetic structure, loosening of abutment screws and the onset of these complications. The test outcomes pointed out that the impact of these effects is typical in only two of the studied dependencies - the presence of parafunctions and non-balanced occlusion. Spearman "Rho" for established cases of parafunctional activity is: rho (218) = 0.413, p <0.001. The correlation sign is positive, which means that increasing this factor brings about the rise in possibility of fracturing the dental implant. In terms of non-balanced occlusion and errors in planning the prosthetic structure Spearman "Rho" is rho (218) = 0.356, p <0.001. Having applied the Cohen's guidance (Cohen, 1988), we found that the size of the effects of the above two indicators is close to average.

Using Kruskal-Wallis' test (Kruskal-Wallis) we traced the influence of crestal resorption, parafunctions, the design of prosthetic structure, screw-loosening and the onset of complications in cases with fracturing the dental implant. It showed that there was a statistically significant difference in analysed parameters: according to the type of prosthetic structure - $\chi 2$ (1) = 5,167, p = 0,023, in terms of parafunctions- $\chi 2$ (1) = 36,933, p <0,001, according to the presence of non-balanced occlusion in prosthetic structures - $\chi 2$ (1) = 27,437, p <0,001, depending on the crestal resorption - $\chi 2$ (1) = 4,623, p = 0,032, in accordance with the screw-loosening - $\chi 2$ (1) = 6,776, p = 0,009 and with the onset of complication - $\chi 2$ (1) = 13,981, p <0,001.

In order to establish the size of the effect of the studied factors influencing the possibilities of fracturing the dental implants we processed the data above using the corrected

by Bonferroni post hoc Mann-Whitney test for each of the individual groups. The results are presented in Table 1.

Table 1. Mean values of the effect size of statistically significant factors leading to the fracturing dental implants for the entire sample:

Comparison of indicators	***Total:*** ***(p-value)***	***SS***	***ES***
Type of prosthetic structure	*,023*	-	*0,154(M)*
Established parafunctions	*,001*	*	*0,416(T)*
Errors in planning prosthetic structure	*,001*	*	*0,355(T)*
Crestal resorption	*,032*	-	*0,146(M)*
Screw-loosening	*,009*	-	*0,176(M)*
Time of complications setting in	*,001*	*	*0,253(T)*

Notes: SS – statistical significance is reported with Bonferroni correction coefficient at α = 0.05 for 6 groups only if p ≤ 0.003, ES - effect size; higher values reflect the greater importance of the factor concerned (-1.00 - minimum value, 0.00 – mean value, 1.00 – maximum value); Data is processed by Mann-Whitney U test; the size of the effect is calculated based on Cohen's coefficient "r" and interpreted in values> 0.70 as much higher than the typical (B), 0.50-0.70 as high (B), 0.30-0.50 as mean or typical (T), from 0.10 to 0.30 as low or lower than the typical (M) according to Cohen (Cohen, 1998).

Discussion

Although the scientific publications disclose a relatively low rate of mechanical complications in implant treatment, their fracture is associated with treatment failure and is extremely frustrating. The established rate of 2.3% in our study is close to the reported in the literature.

The results of the conducted tests indicated that parafunctional activity, errors in prosthetic structure design and time of complications setting in have a statistically significant impact with typical size of the effect observed in cases of dental implant fractures. They confirmed the opinion of some studies that parafunctional activity can be one of the etiological factors leading to biological and biomechanical complications in implant supported prosthesis. This is not surprising at all considering the increased occlusal loading (such as duration and size) and force direction in bruxists. The outcomes also showed statistically significant correlation between errors in prosthetic structure design (cantilever extensions and unlevel occlusal contacts) and fracture of implants. This does not support the opinion of Romanos GE et al. and Romeo E et al. that distally located cantilever units can be applied successfully in implant prosthetics. Any size type of cantilever extension causes towing forces with a direction different from the axial axis of the implant and increases stress in the bone around the implant, leading to crestal resorption.

According to the studies of Jimbo R et al. and Hsu YT et al. the fracture of implants may be preceded by bone loss in marginal zone and this can bring about fracturing the implant. The results of analysis show that crestal resorption as a separate factor has little impact on fracturing dental implants (Table 1), while this was found in varying degrees in all observed cases of such complication (Figure 1). It is noteworthy, however, that this factor

enhances the effect of cantilever extensions (generating forces of unfavorable direction - towing) and combining them could have an impact on fracturing the implant.

In our study it was not established an increased frequency or statistically significant dependence regarding fracturing implants with a smaller diameter, which is supposed to be in favour of studies of Shemtov-Yona K. and Freitas-Junior AC. and confirms the results of Moris IC. and other studies that the implants with a smaller diameter have similar biomechanical resistance in clinical settings to those with a larger diameter.

In regard to the time of fractures setting in the results from the current study are similar to those of Gargallo-Albiol J, according to which a larger percentage of cases occur in the first 1-4 years after the implants having been loaded. This indicates that their fracturing in most cases is due to errors in biomechanical planning and design of prosthetic structure, leading to their increased loading. Concerning the other traced factors it was not detected a significant size of the effect between them and fractures of dental implants in our study.

Conclusion

The precise planning of positions, number and diameters of dental implants, the design of prosthetic structure, as well as reporting parafunctional activity are important for successful treatment. Particular attention should be paid to the occlusion that is supposed to be in optimum harmonic occlusal contacts to prevent undesired in size and direction forces. Using the cantilever extensions should be avoided. In patients with established parafunctions it is advisable to use a greater number of implants as well as subsequent monitoring of this activity with different types of acrylic occlusal splints, which lower the risk of bio-mechanical complications setting in.