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Original paper

A pilot study for the analysis of some biomechanical risk factors regarding the immediate loading of dental implants

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Abstract Immediate loading of dental implants is preferred by many patients to avoid the mobile prosthesis as a provisional solution. The purpose of our study was to initiate a comparative analysis between one of the cases treated (named "the reference case") where a complication occurred (loss of some implants) and a number of 10 other treated cases that progressed normally. It was necessary to answer to the following question: which was the cause of the complication? In all patients several parameters were measured: implant length, crown length, implant number, goniac angle, anterior facial height. Bone density was also evaluated. Two new indices proposed by us were calculated to express the mechanical resistance of the implant assembly embedded into the bone. The implant lever (implant/crown length) and the anterior facial height have been proved relevant. We have defined the "anthropometric coefficient" (AC) as the ratio between the implant lever and the facial height. The most significant result was the value of the anthropometric coefficient (10,2 x 10^{-3} in the reference case versus 17,0 x 10^{-3}average value for the other cases). Also, the lack of patient monitoring for the first 3 months may be significant.

Keywords Implant lever, anterior facial height, anthropometric coefficient.

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Introduction

Due to the advantages they offer for all types of edentation, dental impalnts become more and more demanded by patient (STETIU & al [1]). Regarding immediate implant loading, a review of 2875 published studies shows the intense concern of researchers around the world to define the factors that depend on the success or failure of these treatments (VALKOVA & al [2]). The method consists of the intra-bone application of the dental implants followed by a maximum of 48 hours of "loading" with forces coming from the oral environment, whether there are masticatory forces or coming from soft tissues (tongue and cheeks). In fact, this is justified by the desire of any patient who loses teeth to substitute them as quickly as possible, without major functional and social implications. In 2003, R. GAPSKI & al [3] reviewed the moments that marked the evolution of this technique, as follows: in 1963, Linkow designed a specific self-tapping implant (Ventplant) so that in 1967 to use the blade implant for immediate loading. It seems, however, that fibrous encapsulation occured in many implants (communicated in 1973). In 1997, other authors brought significant contributions (PIATELLI, CHIAPASCO, WEBER). In 1998, S. Moncler incriminated the movements of 150 microns as being responsible for possible failures. In 1999 Branemark himself has revised his protocol, in the same year as Randow and Scortecci.

In 2013, a systematic review (DELL FABRO & al [4]) reported an 99.4% implant survival rate in the aesthetically cured area compared to 95.6% for the same area but post extractionally. Regarding solidarity between implants, in 2014 it was claimed that it is not necessary to use a metal bar in the provisional period, the survival rate being the same as in the case of solidarization by other means (THOME E & al [5]). From all the above statements, we can say that immediate loading has a good rate of success. Also there is an ongoing concern to look for new significant details.

The purpose of our study was to initiate a comparative analysis between one of the cases treated (called the "reference case") where complications occurred and 10 other treated cases that progressed normally. We finally wanted to answer the questions:which was the cause of the complication? It was only the patient's disobedience or it was more than that?

Materials and Methods

The retrospective study was based on one" reference case" and another 10 cases randomly selected from the database of Dr. Dragos Epistatu Clinic from 2007-2017. Every single case was immediately loaded (upper jaw). Criteria for inclusion in the study: good oral hygiene, sufficient bone supply – implants minimum 3.75 mm / 11.5 mm. Exclusion criteria were: systemic disorders, history of malignancies, bruxism, smokers, immunosuppression, pregnancy, oral inflammation.

The first session was intended for clinical and paraclinical examinations (X-ray and blood tests). The second session was for surgical treatment using Exacta implants (BIAGGINI MEDICAL DEVICES) and Nova implants (NOVA IMPLANS MEDICAL DEVICES). The required biomaterials were Bio-Os (GEISTLICH) and the Evolution membrane (OSTEOBIOL). The implants were screwed at least 35 Ncm in bone and teflon /peek (polyether-ethyl-ketone), metal prosthetic posts were applied. Depending on the situation, a small addition of heterologous bone and a bioresorbable collagen membrane were applied. The provisional prosthesis was conceived in two ways, A and B. In version A, the prosthetic field was imprinted and the temporary acrylic prosthesis was cemented the next day with resin cement. In version B, the impression was taken before inserting the implants, the prosthesis being adapted and fixed immediately post-surgical with Maxcem resin cement (KERR-HAWE). The temporary prosthetic works were occlusally balanced and the patient was recommended to avoid exaggerated masticatory forces for 2 months. After 6 months the provisional prosthesis was replaced by the final work. The follow-up examinations were done after 1 week, 3 weeks, and then from the second month onwards until the 6^{th} month. The examinations concerned the stability of the provisional assembly, hygienic control, occlusal equilibrium control. After the application of the final prosthesis, a profile teleradiography was taken for each case at a variable period of time.

From a mechanical point of view, the implants-temporary prosthesis assembly is a rigid system, predominantly subjected to mastication forces induced by the masseter muscles, approximately perpendicular to the Frankfurt horizontal plane (Fr). In the Tweed cephalometric analysis (JACOBSON [6]), the difference between the occlusion plane and the Frankfurt plane (Fr) is small, of 8-12 degrees. If the implants in the lateral area are closer to the perpendicular to Fr, the frontal implants obviously have a different angulation due to the alveolar process, creating an "α" (alpha) (Fig. 1) angle with the perpendicular to Fr. This angle seems to be unfavorable to the overall strength of the assembly since the vertical forces produce a "moment of force" towards anterior.

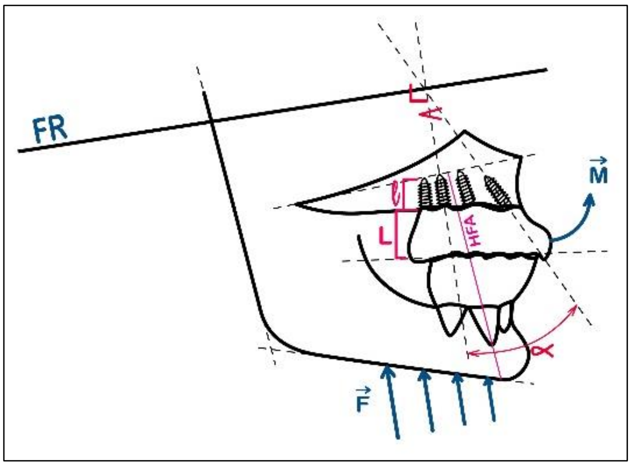

Figure 1. Biomechanics of immediate loading

The list of parameters considered to be important in the resistance of the ensemble was:

- **1.** the length of the implant (l)
- **2.** the length of the crown (L)
- **3.** bone density
- **4.** number of implants
- **5.** diameter of implants
- **6.** goniac angle- which is even greater as the strenght of the masseter muscles decreases. (SASAKI & al [7])
- **7.** alpha angle- produces a mechanical moment anteriorly oriented

Ratio l / L = Implant lever

From classical mechanics we assume that the factors 1, 3, 4, 5, 6 have a directly proportional influence over the resistance of the assembly, contributing to its stiffening. We also assume that factors 2 and 7 inversely influence the resistance of the assembly, contributing to its destabilization. All average values included in the study ($\bar{L}$, $\bar{l}$, $\bar{\alpha}$) were calculated by the arithmetic mean of the values recorded for each inserted implant. The goniac angle is delimited between the ramus and the mandibular corpus. The height of the anterior facial profile (AFH) is the distance from menton to the palatinal plane (JACOBSON [6]). This height is in direct relation to the goniac angle but also to the vertical dimension of the subject. For density, we applied the method described in “The study on the interpretation of bone density on panoramic radiography” (EPISTATU D. & al [8]).

Table 1. Imagistically defined bone densities

D1	• dense aspect, radiopaque, no visible intertrabecular spaces • only in the anterior mandibular area
D2	• dense aspect of well-mineralized bone • small intratrabecular spaces can be distinguished
D3	• medium density appearance • medium mineralized trabeculae and large intratrabecular spaces
D4	• radiotransparent bone appearance, poorly mineralized trabeculae with very wide intratrabecular spaces
D5	• radiotransparent aspect of the bone without bone trabeculae

We assigned to each bone density a number of 1 to 3 depending on the mechanical strength intuitively associated to each density. We expect the density distribution to be of the Gaussian type as shown in Figure 2.

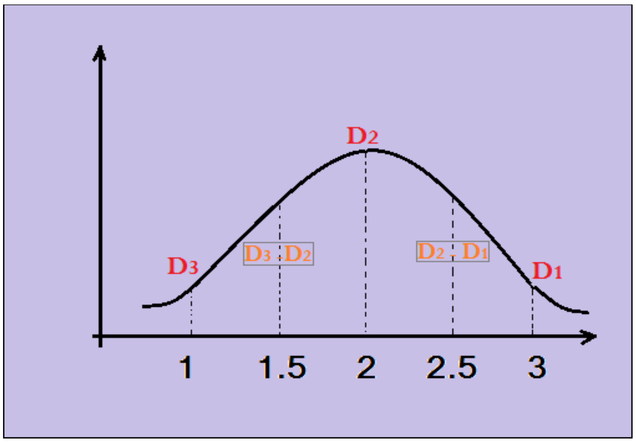

Figure 2. Distribution on the Gauss curve of bone densities with the assigned values.

We have thus defined a RESISTANCE COEFFICIENT k_D, to be calculated for each case by the formula:

$$k_D = \frac{\bar{l} \times \text{number of implants} \times D \times \emptyset\,\text{implant} \times \sphericalangle\,\text{goniac}}{\bar{L} \times \bar{\alpha}}$$

and a RESISTANCE COEFFICIENT k, excluding bone density:

$$k = \frac{\bar{l} \times \text{number of implants} \times \emptyset\,\text{implant} \times \sphericalangle\,\text{goniac}}{\bar{L} \times \bar{\alpha}}$$

It can be observed that coefficient k does not contain a subjective factor (estimation of bone density on X-ray) nor the intuitive assignment of coefficients 1 to 3 in relation to the densities.

Radiographs do not always have a scale of 1: 1. In order to decrease as far as possible these errors, we have introduced a radiography correction factor (R) representing the ratio between the actual size (from the patient record) and the size measured by radiographs of the dental implant. For all of the patients, the parameters discussed above were either extracted from the observation sheet or measured: length of implants (l), diameter, crown length (L), number of implants, goniac angle, anterior facial height (HFA). Bone density was estimated and the indices were calculated: K (D) and K.

Case analysis

The patient L.L. was examined on 04.12.2008 for surgical treatment of the upper jaw. A number of 9 implants were placed, of which 6 were immediately loaded with a cemented provisional restoration in the same session.

Figure 3. Case analysis: **A.** initial panoramic X-ray of L.L; **B.** patient L.L. after implant placement; **C.** patient L.L. after the complication occured

On 13.03.2009, implants 11, 14, 21, 24 showed mobility. They were removed and a bone addition was done. After approximately 7 months (07.10.2009), implant 13 was also removed. Some implants were replaced and the case was finalized in good condition.

Figure 4. Lateral cefalometry of patient L.L.

Table 2. Patient L.L. parameters

Patient L.L	l (mm)	L (mm)	R	L.real(mm)	Diameter	Alpha(degrees)	Gonion	Density	Nr.of impl	HFA(mm)	K(D)	K
incisor 11	11	16			4,7mm	16						
incisor 21	11				4,7mm	16						
canine 13	13				4,35mm	20						
canine 23	11				4,7mm	20						
premolar 15	11				4,35mm	15						
premolar 25	11	14			4,35mm	15						
Considered average	**11,33mm**	**15**	**10%**	**13,5mm**	**4,61mm**	**17**	**124 degrees**	**index 2**	**6**	**81**	**338**	**169**

Similar anlayses and measurements were performed for other cases. All data is centralized in Table 3. The average of the parameters of all cases without complications has also been calculated. A ratio comparision of the values for the reference case and the average of the other cases was made and the following were observed. Average length in the reference case is found to be the lowest of all the cases.

Table 3. Measured and calculated parameters of all cases

Patient	l (mm)	L real(mm)	l/L	Diameter(mm)	Alpha(degrees)	Gonion(degrees)	Density	Nr. of impl.	HFA	K(D)	K	C.A
Reference :L.L	**11,33**	**13,5**	**0,83**	**4,61**	**17**	**124**	**2**	**6**	**81**	**338**	**169**	**0,0102**
Cases:												
S.Gh	12,25	13,05	0,93	4,1	11,5	112	2	6	65	479,95	239,9	0,0142
M.Gh	11,8	11,25	1,04	4,2	17,75	124	2	6	74	376	188	0,0141
C.E	12,4	9,9	1,25	4	28	122	2	5	69	214	107	0,018
D.M	12,75	12,6	1,01	4,125	14,5	124	1,5	6	67	321,26	214,2	0,0151
F.G	11,5	9	1,27	3,9	26,5	119	1,5	4	56	134,83	89,8	0,022
I.R	11,5	10,8	1,27	4,2	15,5	130	1,5	6	68	337,58	225	0,0155
M.Mi	13	10,5	1,23	4,05	29,3	115	1,5	6	68	210,96	140,6	0,018
P.M	13	12,15	1,23	4,3	19,5	128	2,5	8	73	586,36	234	0,014
S.D	12,6	8,5	1,48	4,42	24,8	126	2,5	5	70	416	166	0,021
S.V	12	9,45	1,26	4,64	20,5	122	2	6	68	417	208	0,0185
Average of the cases	**12,2425**	**10,72**	**1,197**	**4,1865**	**20,785**	**122,2**	**1,9**	**5,8**	**67,8**	**349,39**	**181,2**	**0,017**
LL/ Average of the cases	**0,92**	**1,25**	**0,78**	**1,1**	**0,81**	**1,01**	**1,05**	**1,03**	**1,29**	**0,96**	**0,93**	**0,61**

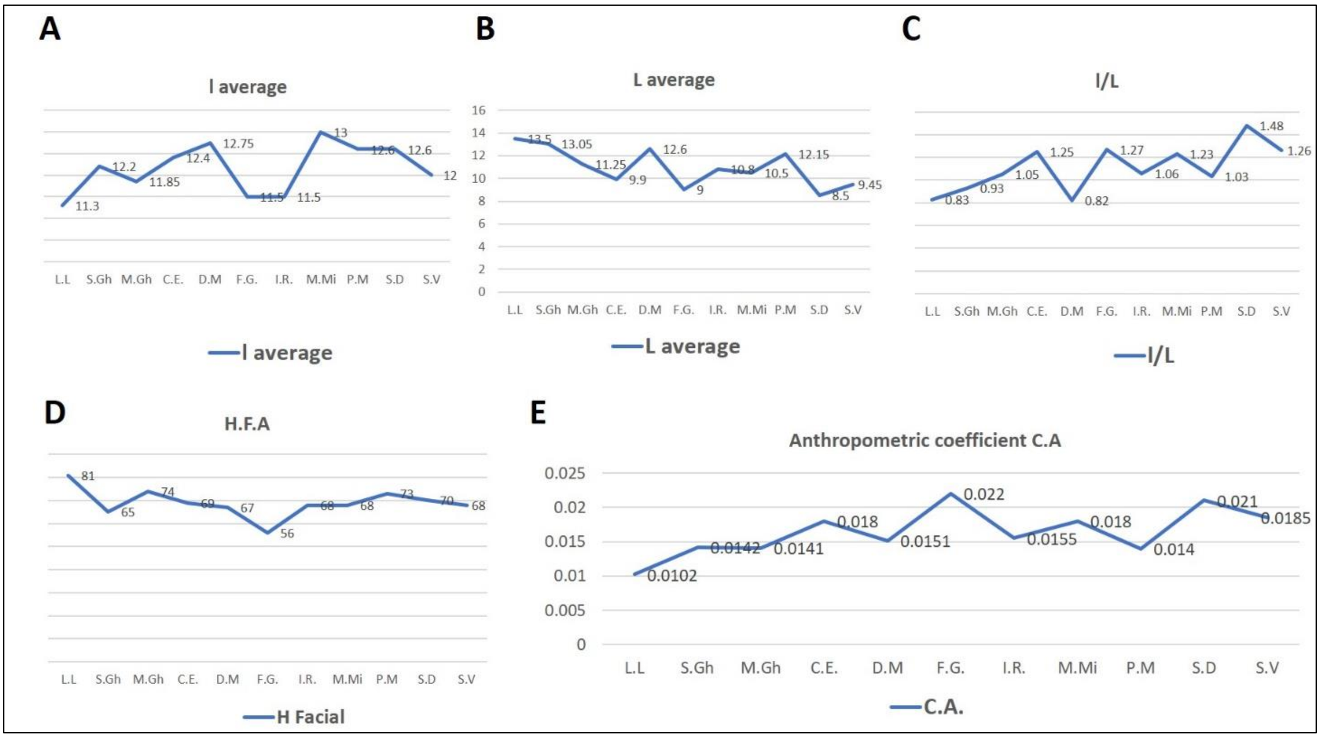

Figure 5. Biomechanical risk factors regarding the immediate loading of dental implants- a comparative analysis. **A.** Average length variations of the implants; **B.** Average length of the crowns; **C.** The ratio of implant length (l) and crown length (L) (implant lever); **D.** the anterior facial height; **E.** Anthropometric coefficinet C.A.

The averenge length of the crowns in L.L. case was the biggest, 25% above all the cases. The implant lever (l/L ratio) was found in the reference case (L.L.) closer to the lower limit of the interval of variation (Figure 5A). The diameter of the implants in the reference case (L.L.) was the greatest, that should have been an advantage accordimg to the literature (DING X & al [9]); it means this value does not explain the emergence of complications (Figure 5B). The alpha angle of the reference case (L.L.) was also within the variation interval, being even below the average value; so the forces on the frontal implants were more favorable along the axis comparing with other cases, which cannot explain the destabilization occurred (Figure 5C). The goniac angle in the reference case (L.L.) was almost the same as the average of the cases, so it is irrelevant; the same with the density and number of the implants. The anterior facial height (HFA) was remarkable in the reference case (Figure 5D). This fact may be relevant, the control patient beng a macrosomic person. In case of variation of K(D) and K indices, both parameters harbored a similar variation, but they are also within the interval, so they were inconclusive.

At the end of the study we decided the calculation of a new ratio, in order to express the results more synthetically. Thus, we divided the l/L ratio by HFA and we called it anthropometric coefficient (CA.). We observed that the lowest value of the anthropometric coefficient appeared in the reference case, meaning only 61% of the registered average of the other cases.

Conclusions

This is a pilot study the we belive is relevant to orientate clinicians regarding some possible extreme cases and deserves of be developed on a biggest number of cases. We have observed that the l/L lever of implant ratio is smaller in the reference case and that the anterior facial height (HFA) in the reference case was 29% above the average of the cases. The anthropometric coefficient seems to be relevant in the referece cases,(10,2 x $10^{3)}$, totally out of the variation interval (14,1 x 10^3 – 22 x 10^3). The diameter of the implants has not been shown to be significant whereas lack of patient monitoring in the first 3 months may have significance, the hypotheses of patient’s disobedience in the reference case is not excluded.

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For this article all the authors have equal contributions to the first author.

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