# Comparative Studies of Various Methods of Mounting The Implant Mandrel within The Bone

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**Abstract:**

*The paper presents results of studies pertaining to evaluation of a quality (compressive strength of mounting the implant within the bone) of mounting the implant mandrel within the osseous tissue for various relevant techniques. The presented results are related to selected techniques of mounting the implant mandrel within a bone. The comparison has been carried out for cement-less mandrels with a smooth mandrel of the endoprosthesis, porous cement-less endoprostheses as well as mandrels made of bioactive materials.*

**Keywords**: *mounting of an implant mandrel within the osseous tissue, endoprosthesis, implant-bone contact*

## 1. Introduction

A development of the biomedical engineering makes many numerous types of implant mandrels available. They employ various techniques of mounting within the osseous tissue. The paper contains a comparison of the most often applied techniques of mounting the implant mandrel within the osseous tissue. The main aim of the paper has been a comparison of one of the parameters describing the quality of the mounting of the implant within the osseous tissue for various techniques of joining the mandrel with the osseous tissue. A list of the same parameters describing the quality of the mounting for each particular technique of mounting allows one to univocally evaluate, which solution is the most effective, and its application for selected individual characteristics of a patient will make the implantology more successful.

## 2. Methodology of the studies

The comparative studies of various ways of mounting the implant mandrel within the osseous tissue was preceded by an overview of the relevant techniques of mounting the mandrel within the osseous tissue. For further studies, one has chosen, among other things, methods that are commonly applied in the implantology and a prototype method based on resorbable materials. The following techniques were selected:

– mounting of an implant with a smooth surface of the mandrel,
– mounting of an implant with a porous surface of the mandrel,
– mounting of an implant with a superficial layer made of a resorbable material [1,2,4].

The choice was determined by the fact that an analysis of the data obtained during various methods of experimental studies would not univocally define which solution is superior over the rest. An imprecise description of the parameters that can be found in the related literature could result in an erroneous evaluation of a solution. In order to prevent against such situation, one elaborated his own methodology of experimental studies that was applied for the above selected techniques of mounting the implant mandrel within the osseous tissue [7]. A reliable comparison is possible only when we know how given factors influence a studied parameter, or when all the factors are constant for all the studied objects. The experimental comparative studies presented later in the text were performed according to a methodology, where the factors influencing the studied object were the same for all the tests, and the tests on the studied objects were performed with application of

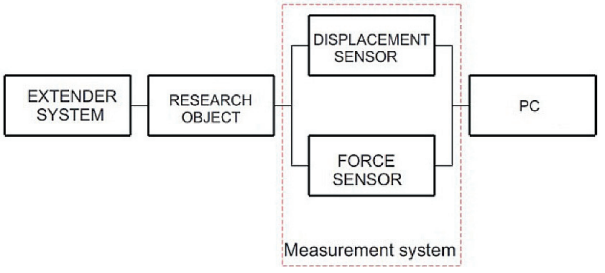


*Fig.1. Block diagram of the test station for determining displacements of the mandrel with respect to the osseous tissue, which it was mounted in*

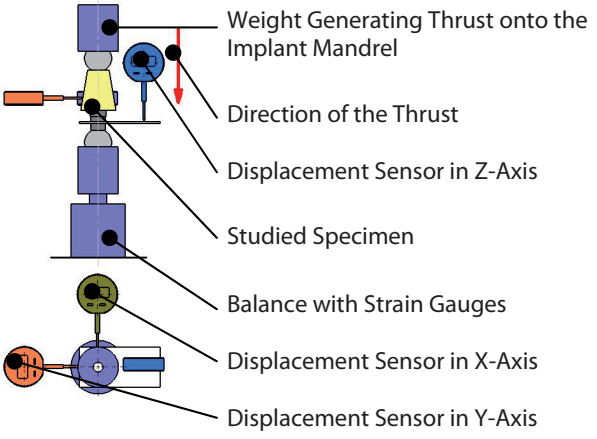


*Fig. 2. Diagram of realization of the recording of the displacements of the mounted mandrel with respect to the osseous tissue*

the same technique, while keeping identical conditions in repeatable studies.

Realization of the studies consisted in a compression test of a studied object that had been prepared beforehand, and recording a displacement of the mandrel mounted within the osseous tissue with respect to the tissue. The measurements were performed using a system being a part of a whole test station (Fig.1).

In order to verify the obtained results, the displacements were recorded repeatedly for the same technique of mounting. The tests were repeated for the techniques of mounting the mandrel within the osseous tissue, which had been selected beforehand. The applied load exerted by the weighted mandrel generated a thrust onto the osseous tissue.

The data obtained during the studies were automatically recorded in real-time (Fig. 2).

## 3. Object of the studies

The object of the studies were three techniques of mounting the mandrel within the osseous tissue. In order to realize laboratory studies there were prepared objects reproducing the particular techniques of mounting the mandrel within the osseous tissue.

There were made three specimens for each technique.

As the object of studies reproducing the mounting of a smooth mandrel within the osseous tissue, there was applied a sleeve (imitating a fragment of the mandrel) mounted with the closer shaft of a cow thigh bone. A fragment of the closer shaft of the thigh bone originated from a freshly taken cow osseous tissues. The sleeve was made of a high-quality implant steel (cobalt alloy) complying with ISO 5832-12 standard. Mounting of the sleeve within the osseous tissue was realized with the same technique as implantation of the endoprosthesis during a real surgery (Fig. 3).

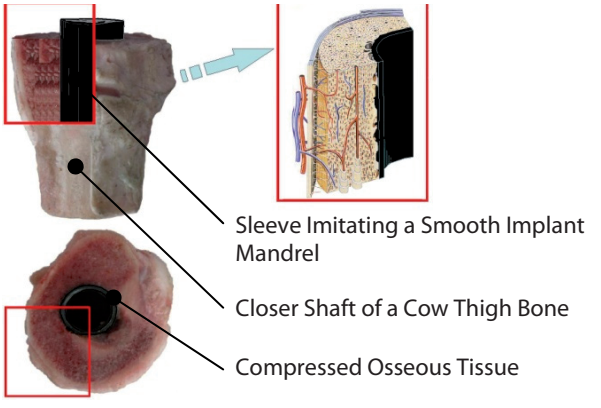


*Fig. 3. Structure of the studied object presenting a cement-less technique of mounting a smooth mandrel within the osseous tissue*

The second studied object was a cement-less mounting of a porous mandrel within the osseous tissue (Fig. 4). The cylindrical sleeve had pores of ca. 1 mm created on its surface.

The third studied object was mounting of a cylindrical frame filled with a material resorbable in the osseous environment. The cylindrical frame was made out of a cobalt alloy (ISO 5832-12 standard). The material filling the frame was a synthetic osseous substitute by the name of Bio-Oss (Fig. 5)[3, 4].

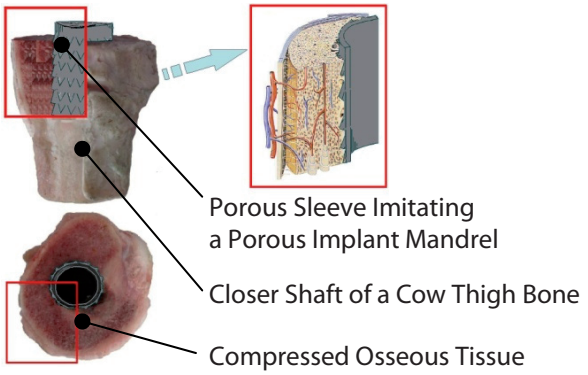


*Fig. 4 Structure of the studied object presenting a cement-less technique of mounting a porous mandrel within the osseous tissue*

There were made three pieces of each object of studies presented above. The objects, before and after the tests, were stored in temperature of 3-5°C and relative humidity of 90%, in order to inhibit the process of decaying and oxidation of a fresh osseous tissue [4,5].

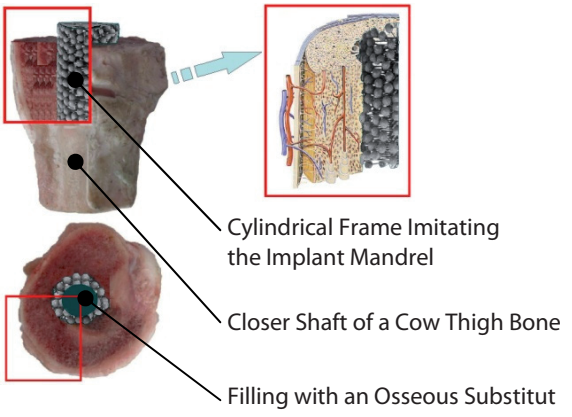


*Fig. 5. Structure of the studied object presenting a technique of mounting a mandrel with a layer of resorbable material*

## 4. Results of the studies

The studies carried out allowed one to create a characteristic of the displacements of the mounted mandrel with respect to the bone, which the mandrel was mounted in. In the following tables (Tab. 1-3) there are listed averaging values of the displacements of the mounted mandrel with respect to the bone, which the mandrel was mounted in. The tables present results obtained for three studied solutions.

*Tab.1. Averaging values of the displacements for the first solution of the mounting, calculated on the basis of three tests*

| No. | Type of the object of studies | Applied load [N] | Resultant displacement [mm] |
|---|---|---|---|
| 1 | Object with a porous smooth surface of the mandrel | 0 | 0 |
| 2 | | 30 | 0.00977 |
| 3 | | 60 | 0.078163 |
| 4 | | 90 | 0.034196 |
| 5 | | 120 | 0.151441 |
| 6 | | 200 | 0.24426 |
| 7 | | 300 | 0.478749 |
| 8 | | 400 | 0.571568 |
| 9 | | 500 | 0.571568 |
| 10 | | 600 | 0.718124 |

*Tab. 2. Averaging values of the displacements for the second solution of the mounting, calculated on the basis of three tests*

| No. | Type of the object of studies | Applied load [N] | Resultant displacement [mm] |
|---|---|---|---|
| 1 | Object with a porous surface of the mandrel | 0 | 0 |
| 2 | | 30 | 0.058622 |
| 3 | | 60 | 0.058622 |
| 4 | | 90 | 0.058622 |
| 5 | | 120 | 0.097704 |
| 6 | | 200 | 0.381045 |
| 7 | | 300 | 0.644846 |
| 8 | | 400 | 0.688813 |
| 9 | | 500 | 0.688813 |
| 10 | | 600 | 0.688813 |

*Tab. 3. Averaging values of the displacements for the third solution of the mounting, calculated on the basis of three tests*

| No. | Type of the object of studies | Applied load [N] | Resultant displacement [mm] |
|---|---|---|---|
| 1 | Object with the cylindrical frame and osseous substitute | 0 | 0 |
| 2 | | 30 | 0.039082 |
| 3 | | 60 | 0.039082 |
| 4 | | 90 | 0.039082 |
| 5 | | 120 | 0.039082 |
| 6 | | 200 | 0.068393 |
| 7 | | 300 | 0.087934 |
| 8 | | 400 | 0.092819 |
| 9 | | 500 | 0.801172 |
| 10 | | 600 | 0.810943 |

## 5. Analysis of the obtained results

The obtained results allowed one to determine value of the displacements in the direction of the applied load for various mountings of the mandrel within the osseous tissue with respect to the exerted thrust (Fig. 6). The following chart shows a trend of variations of the displacements that take place between the bone and the mandrel that is mounted within it. There is also visible a limit of losing a stable mounting of the mandrel within the osseous tissue.

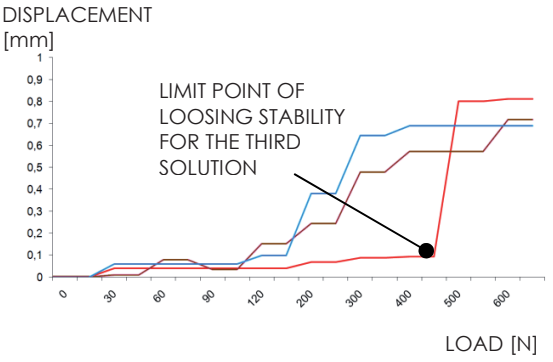


*Fig. 6. Results of measurements of the displacements of the mounted mandrel with respect to the osseous tissue as dependent on the applied load*

## 6. Discussion

Mounting of the implant within the osseous tissue operates correctly only when it receives certain supply of mechanical energy as a result of the acting forces, whose magnitude, time and frequency of acting are within appropriate intervals. The performed studies proved that each of the studied solutions presents an approximate character of collaboration between the implant and the osseous tissue. The most advantageous solution is the one that features stability limits at the possibly highest load. As far as the studied types of mounting are concerned, the most advantageous behavior was that of the object of studies having the mandrel with a layer of a resorbable material [6].

## 7. Conclusions

A challenge in the experimental studies where osseous tissues are used is a variability of the structure of the osseous tissue over the time. In an organism, the osseous tissue, owing to processes of modeling, can progressively adapt to external conditions taking on a form and structure optimal for particular conditions. Therefore, implantation disturbs the optimal structure of the osseous tissue, resulting in micro-injuries and changes in the distribution of the stress within the osseous tissue. It disturbs also the equilibrium of the mechanical energy between the tissue structure and a function fulfilled in the motion system [1,4,5,6]. Maintaining variable and advantageous stimuli having a certain dynamics of interactions is possible owing to application of an appropriate implant mandrel and its mounting within the osseous tissue. In the paper, one presented a characteristic courses of the interactions between the implant mandrel and the osseous tissue as a result of the applied load. One compared characteristics of behaviors of particular solutions of mounting the mandrel within the osseous tissue.

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## References

[1] Marczynski W., *Leczenie zaburzeń zrostu i ubytków tkanki kostnej*, Wydawnictwo Bellona, Warsaw 1995 (in Polish)
[2] Morloock M., Schneider E., Bluhn A., *et al.*, "Duration and frequency of every day activities in total hip patients", *Journal of Biomechanics*, vol. 34, 2001, pp. 873-881.
[3] Pietruska M.D., "A comparative study on the use of Bio-Oss® and enamel matrix derivative (Emdogain®) in the treatment of periodontal bone defects", *European Journal of Oral Science*, vol. 109, no. 3, 2001, pp. 178-181.
[4] Zaczyk M., Jasińska-Choromańska D., Zjawisko kontaktu endoproteza-kość. In: *Materiały II seminarium inżynierii wytwarzania*, Kalisz 2008, Poland, pp. 230-236. (in Polish)
[5] Zaczyk M., Jasińska-Choromańska D., Miśkiewicz A., „Stanowiska do badań jakości osadzenia trzpienia implantu w kości". In: *Materiały konferencyjne Majówki Młodych Biomechaników*, Ustroń 2011, Poland. (in Polish)
[6] Zaczyk M., Jasińska-Choromańska D., Kołodziej D., „Ocena dokładności wyników eksperymentalnego badania połączenia implant-kość", *PAK*, vol. 57, no. 9, 2011. (in Polish).