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Case Report / Приказ болесника

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Challenges in irradiated bone implantation

Изазови у имплантацији зрачене кости

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SUMMARY

Introduction Implantation in irradiated bone is very challenging due to many factors: implant therapy parameters, irradiated tissue, and the patient's general health. Implantologists have to consider all of these aspects when planning implant therapy and during the postsurgical recovery period.

Case outline A case presented in this paper is a 54-year old male, who was admitted to the Clinic for maxillofacial surgery, School of dental medicine in Belgrade, for implant anchored orbital prosthesis. One year previously, the patient had orbital exenteration and postoperatively received radiotherapy with an overall dose of 60 Gy. After planning, three disk implants - two double and one triple disk were placed (Ihde Dental, Switzerland). Implant stability was clinically satisfactory with immediate ISQ of 37, 46, and 51, respectively. After osseointegration implant retained prosthesis was manufactured. After six years due to osteoradionecrosis (ORN) implant stability was compromised. The patient received conservative and hyperbaric chamber treatment. The implants regained stability, and the patient was in remission for four years. Afterwards due to ORN two implants were explanted, and the third implant was stable enough to anchor the prosthesis. The prosthetic plan had to be modified for one implant anchorage, afterwards successful prosthetic rehabilitation was achieved.

Conclusion Implantation in irradiated bone is very delicate, and careful planning of implant insertion and prosthetic rehabilitation is essential. The possible occurrence of osteoradionecrosis should also be taken into account, as a result of which the implant may be lost, which compromises the retention of the prosthesis.

Keywords: extraoral implants therapy; osteoradionecrosis (ORN); bone implantation

САЖЕТАК

Увод Имплантација у зраченој кости је велики изазов због многих фактора: параметара имплантолошке терапије, зраченог ткива и општег здравственог стања пацијента. Имплантолози морају да узму у обзир све ове аспекте приликом планирања имплантолошке терапије и током постхируршког периода опоравка.

Приказ болесника случај приказан у овом раду је мушкарац стар 54 године, који је примљен на Клинику за максилофацијалну хирургију Стоматолошког факултета у Београду ради постављања имплантатима ретиниране орбиталне протеске надокнаде. Годину дана раније је имао егзентерацију орбите и примао је радиотерапију са укупном дозом од 60 *Gy-Gray*. Након пријема на клинику и планирања терапије постављена су три диск имплантата (*Ihde Dental Switzerland*) (два дупла, један троструки). Опоравак пацијента био је задовољавајуци са клинички стабилним имплантатима (имедијатно *ISQ* 37, 46, 51). Након осеоинтеграције протеза ретинирана имплантатима је направљена. Након шест година због остеорадионекрозе стабилност имплантата била је угрожена. Пацијент је добио конзервативни и хипербарични третман. Имплантати су повратили стабилност, пацијент је био у ремисији четири године. Након тог периода због ОРН два имплантата су експлантирана, а трећи имплант је био довољно стабилан да ретинира протезу. Протетски рад је морао бити модификован за сидрење помоћу једног имплантата имплантата, након чега је постигнута успешна протетска рехабилитација.

Закључак Имплантација у озраченој кости је веома деликатна, а пажљиво планирање уградње имплантата и протетске рехабилитације је неопходно. Треба узети у обзир и могућу појаву остеорадионекрозе, услед чега може доћи до губитка имплантата, што нарушава ретенцију протезе.

Кључне речи: екстраорална имплантолошка терапија; остеорадионекроза; имплантација у кости

INTRODUCTION

Therapy of malignant tumours includes radical surgical resection, with adjunctive specific oncologic therapy such as irradiation and polychemotherapy. After tumour resection, irradiation therapy is applied to reduce the probability of relapse [1, 2, 3]. A bone that has been irradiated does not have the same qualitative characteristics as an intact bone. The negative effect of X-rays on bone tissue, skin and mucosa leads to tissue hypoxia and a decrease in the number of cellular elements [3, 4, 5]. In soft tissues, they cause wounds that are difficult to heal and compromise circulation. The success of implant therapy in such tissue depends on several factors: the quality of the bone, the blood supply to the bone tissue, as well as the number and preservation of the cellular elements of the bone [1, 2, 3]. Irradiated bone has reduced the proliferation of bone marrow, collagen, periosteal and endosteal cells. All this makes osseointegration difficult. A hyperbaric chamber significantly helps osseointegration in irradiated tissue. Some authors advise implantation in an irradiated area after 4–6 months after the completion of radiation therapy, although many studies show good results even after the immediate implantation. Sometimes due to the high dose and frequency of radiation, osteoradionecrosis occurs [5, 6, 7]. The bones around the orbital cavity are the most prone to radiation damage. The effect of radiation dose is expressed as the "cumulative radiation effect" CRE. A statistically significant dose of radiation for implant failure is 50 Gy and more [8, 9].

CASE REPORT

A 54-year-old male was referred to the Clinic for maxillofacial surgery, School of dental medicine Belgrade, for prosthetic rehabilitation after orbital exenteration. Previously, he was operated on for recurrent Squamous cell carcinoma of the left eyelid with orbital propagation. After surgery, he received radiotherapy in 30 sessions for 6 weeks, 5 times a week, with an overall dose of 60 Gy. One year after irradiation, the patient was admitted for implant therapy and prosthetic rehabilitation. The study was reviewed and approved by the ethics committee of the School of Dentistry, University of Belgrade (No. 36/14).

After preoperative CT evaluation and planning, implantation was performed in general endotracheal anaesthesia in April 2012. Three disk implants (Ihde Dental, Switzerland) were placed (two double disk implants, and one triple disk implant) in the standard implantation protocol for disk implants. After bone exposure, implant site preparation was done with minimal trauma using specific drills (vertical cutter and lateral cutter) using a high-speed contra-angle (1:1, up to 40.000 RpM), with constant and vigorous cooling by cold saline solution (4°C). The implants were then hammered into the prepared cortical implant bed (Figure 1a.b.c). Immediately after placement, implant stability was measured using Ostell mentor AB, (Gothenburg, Sweden). Implant stability quotient (ISQ) of 37 and 46 (for double disks) and 51 (for triple disk) was found respectively. Implants were then covered under the skin for healing. Double disk implants were inserted supraorbital in the lateral aspect of the frontal bone and triple disk in the body of the zygomatic bone.

Prophylactic antibiotic therapy with Amoxicillin with clavulanic acid (Amoxiclav, Sandoz, Switzerland) was prescribed - 1 gram every 12 hours.

After completing osseointegration, six months later, control radiography - Waters projection showed good implant position as well as osseointegration (Figure 2). Implants were exposed and cutaneous formers were placed onto them, to prepare for impression taking. The middle, double disk implant, was left submerged as backup retention for prosthesis anchorage.

Before the process of orbital prosthesis production, ISQ measuring for the two exposed implants was performed. Double disk showed 39 and triple disk 55. After impression taking planning and modelling the substructure on the master model was done. The acrylic base plays the role in both magnet and silicon prosthesis holders' platform. A magnet for retention – Co-Sm magnet (Technovent, UK) was attached to the acrylic base by self-curing acrylic resin. The other part of the magnet was bonded to the housing at the metal substructure by composite glue. After the wax sculpting winding-up, the orbital prosthesis was converted to additional silicone with a previously selected colour. Implant anchored metal substructure for prosthesis retention was set on the patient (Figure 3ab).

Prosthesis served very well for six years with no complaints from the patient. However, in 2018. due to subsequent osteoradionecrosis implants were compromised. The values of ISQ for double disk were 30 and for triple disk was the almost same – 53, because the implant was not in an area affected with radio osteoradionecrosis.

The patient was treated with local conservative treatment comprised of curettage and debris removal as well as with 3% oxygen and betadine rinse. Therefore, the patient has undergone a hyperbaric oxygen chamber (HBOT - 20 sessions - 70 minutes per session). Through the mask, 100% oxygen was administrated with a pressure of 2.2 ATA -atmosphere absolute. After the applied therapy clinical signs of osteoradionecrosis resolved and the patient used the prosthesis normally. ISQ measures were 36 and 55 respectively (Figure 4).

Four years later (June 2022) due to osteoradionecrosis exacerbation (Figure 5) both double disc implants had to be removed, because they were clinically unstable due to bone damage. Nevertheless, the triple disc implant was still stable (ISQ 55), given that the zygomatic bone in which it was anchored was not affected by radionecrosis. The triple disk implant was stable enough to take over the prosthesis anchorage. In addition, the prosthesis substructure had to be readjusted due to the smaller number of retaining implants. The acrylic part of the prosthesis was somewhat reduced, which made the prosthesis lighter. Afterwards, the triple disk implant showed good clinical stability for the orbital prosthesis retention (Figure 6).

DISCUSSION

Even for experienced surgeons it is challenging when they are faced with implantation in irradiated bone. Careful planning and implant therapy parameters (bone amount, implant type, implantation technique and protocol) have to be taken into consideration. Also, irradiated bone issues are of great importance; some bones are more prone to osteoradionecrosis than others; the amount of radiation dose – if over 50 Gy, the risk of osteoradionecrosis (ORN) is much higher; the frequency and period of radiation therapy also play an important role in the risk of ORN [1, 2, 3].

Correspondingly, the success of implant therapy in irradiated tissue depends on the quality of the bone. The highly mineralized bone, like zygoma, is typically very resistant to infection and stable to resorption. This is why disk implants which are placed in compact bone, are, in our opinion the method of choice [1, 9]. Nevertheless, the blood supply to the bone tissue is one of the essential factors, as well as the number and preservation of the cellular elements of the bone. Irradiated bone has reduced the proliferation of bone marrow, collagen, periosteal and endosteal cells. Due to these factors, bone after radiation therapy is specifically prone to osteoradionecrosis. General health factors like age or chronic illness (diabetes), risk of relapse, and nicotine consumption, are also contributing to the failure of implant therapy in irradiated bone [5–9].

The difference is that double disk implants (two explanted) generally have slightly smaller ISQ values than triple disks because of a reduced number of retaining disks. Furthermore, two double disk implants were placed in the orbital part of the frontal bone and the triple disk implant was in the body of the zygomatic bone which made all of the difference. In the orbital part of the frontal and zygomatic bone, our previous studies showed a high cortical thickness of 1.9 and 2.7 mm respectively. The zygomatic bone has thicker compact bone compared to the frontal bone, it is less porous (5.7% compared to 6.7%) which gives better support for integrated implants [1, 2, 3]. Also, while radiotherapy the zygomatic bone was not affected as much as the orbital part of the frontal bone since it was not in the main focus of irradiation, so we assume that’s one of the reasons why it was not so susceptible to ORN.

Conservative treatment in combination with antibiotic therapy is helpful. Hyperbaric oxygen (HBO) therapy involves breathing pure oxygen in a pressurized dive chamber [10–13]. This specialized chamber promotes healing by allowing more oxygen to dissolve in the blood, which results in more oxygen being delivered to tissues. HBO is often used as the first line of treatment for ORN, but there is debate about how effective it is. Treatment usually consists of daily "dives" for a total of 20 to 40 dive sessions over several weeks [12, 13, 14].

Some implantologists insert an extra (submerged) implant as a precaution as a reserve for eventual use when implant failure is expected. In the presented case, we couldn't use a submerged implant because it was also affected by osteoradionecrosis. However, the fact that the triple disk survived, allowed the patient to continue using the orbital prosthesis. In our opinion, the zygomatic bone is the ideal place for extraoral implants because of its somewhat higher compact bone thickness and lower porosity compared to the orbital part of the frontal bone, as those are the main two areas for disk implant placement.

From the prosthetic point of view in such cases, the prosthesis has to be lighter which was accomplished by a maximum possible reduction in volume to relieve the remaining implant, but still preserve the function. Some authors resort to making hollow lightweight prostheses to decrease the load of the implants [14, 15].

To conclude this case presentation, implantation in irradiated bone is very delicate, and careful planning of implant insertion and prosthetic rehabilitation is essential. The possible occurrence of osteoradionecrosis should also be taken into account, as a result of which the implant may be lost, which compromises the retention of the prosthesis.

Conflict of interest: None declared.

REFERENCES

1. Ivanjac F, Konstantinović V. Microcomputed tomography cortical bone evaluation for craniofacial implantology. Srp Arh Celok Lek. 2020; 148(11-12):679-683. Doi: https://doi.org/10.2298/SARH191218056I
2. Padala S. R, Asikainen P, Ruotsalainen T, Mikkonen J. JW, Silvast T. S, Koistinen A. P, et al. Effects of irradiation in the mandibular bone loaded with dental implants. An experimental study with a canine model. Ultrastructural Pathology. 2021; 45:4-5, 276-285. DOI: 10.1080/01913123.2021.1962467 PMID: 34423726
3. Konstantinović V, Ivanjac F, Lazić V, Đorđević I, Palka L. Survival rate of disk and screw type implants used for the retention of extraoral prosthesis. Journal of prosthetic dentistry. 2020; 127(3):499-507. DOI: https://doi.org/10.1016/j.prosdent.2020.07.023 PMID: 33323178
4. Toneatti D. J, Graf R. R, Burkhard JP, Schaller B. Survival of dental implants and occurrence of osteoradionecrosis in irradiated head and neck cancer patients: a systematic review and meta-analysis. Clin Oral Invest. 2021; 25, 5579–5593. https://doi.org/10.1007/s00784-021-04065-6 PMID: 34401944
5. De Luke D, Carrico C, Ray C, Stilianoudakis S, Holler S, Padilla L, et al. Is dose volume a better predictor of osteoradionecrosis risk than total dose for patients who have received head and neck radiation? Journal of Oral and Maxillofacial Surgery. 2022; 80. 9. 1557-63. https://doi.org/10.1016/j.joms.2022.04.009 PMID: 35594907
6. Hongyang M, Van Dessel J, Shujaat S, Bila M, Sun Y, Politis C, et al. Long-term survival of implant-based oral rehabilitation following maxillofacial reconstruction with vascularized bone flap. International Journal of Implant Dentistry. 2022;10.1186/s40729-022-00413-7. doi: 10.1186/s40729-022-00413-7 PMID: 35378661
7. Neckel N, Wagendorf P, Sachse C, Stromberger C, Vach K, Heiland M, et al. Influence of implant-specific radiation doses on peri-implant hard and soft tissue: An observational pilot study. Clin.oral implant research. 2021; 32. 2. 249-261. https://doi.org/10.1111/clr.13696 PMID: 33278849
8. Shokouhi B, Cerajewska T. Radiotherapy and the survival of dental implants: a systematic review. British Journal of Oral and Maxillofacial Surgery. 2021; 60. 4: 422-429. https://doi.org/10.1016/j.bjoms.2021.09.006 PMID: 34903387
9. Dumoulin S, Van Maanen A, Magremanne M. Dental prevention of maxillo-mandibular osteoradionecrosis: a ten-year retrospective study. J Stomatol Oral Maxillofac Surg. 2021;122:127–134. doi: 10.1016/j.jormas.2020.05.022. PMID: 32535252
10. Nikolaenko S. A, Khalapyan A. A, Ilchenko O. A, Shapiro L. A. Application of a universal system of epitesis fixation in the rehabilitation of patients with maxillofacial defects. Stomatologiia. 2022; 101.2: 36-41. DOI: 10.17116/stomat202210102136 PMID: 35362701
11. Ivanjac F, Radenkov T. Correction of posttraumatically scarred upper lip with hyaluron filler. Srp Arh Celok Lek. 2020; 149.1-2. 102-104. Doi: https://doi.org/10.2298/SARH191212082I
12. Giacon T. A, Giancola F, Paganini M, Tiengo C, Camporesi E. M, Bosco G. Hyperbaric Oxygen Therapy and A-PRF Pre-Treated Implants in Severe Periodontitis: A Case Report. International journal of environmental research and public health. 2021; *18*(2) 413. doi: 10.3390/ijerph18020413 PMID: 33430249
13. Pejović T, Kovačević S, Brkić P, Nesović-Ostojić J. Hyperbaric oxygenation as the pretreatment and therapy in ischemia-reperfusion injury. Zdravstvena zaštita. 2022; *51*(3), 54-65. DOI: https://www.doi.org/10.5937/zdravzast51-40055
14. Latinović M, Mitrić-Asković M, Ivanov O, Novaković M, Ličina, J. Oral complications in irradiated head and neck cancer patients-3D conformal radiotherapy planning vs. 3D conformal radiotherapy planning with magnetic resonance fusion. Srp Arh Celok Lek. 2017; 145(5-6), 247-253. https://doi.org/10.2298/SARH160601054L
15. Milić-Lemić A, Sredojević S, Radović K, Stamenković D, Miličić B, Popovac A, et al. Retention force of overdenture retained with telescopic crowns – a comparison of polyether ether ketone and zirconia ceramic telescopic crowns. Srp Arh Celok Lek. 2020; 148(7-8), 410-416. DOI: 10.2298/SARH190923025M

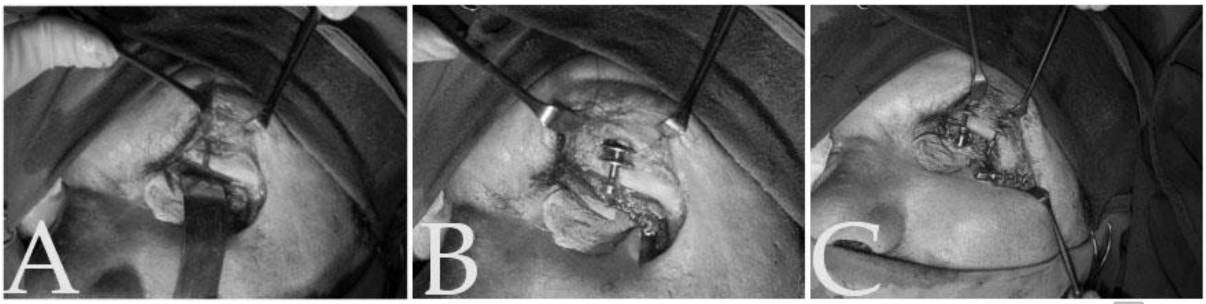

Figure 1. A: bone prepared for implant placement; B: double disk implant placement; C: all implants placed in implant seats

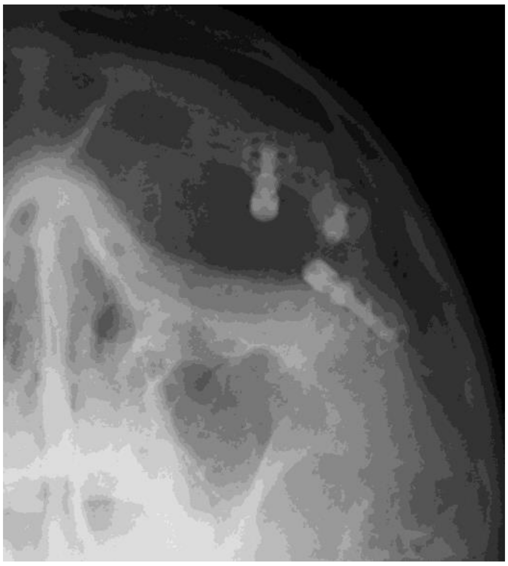

Figure 2. Waters projection radiography with placed implants

Figure 3. A: implants prepared for metal substructure placement; B: metal substructure placed for prosthesis retention

Figure 4. Patient in reemision after hyperbaric and conservative therapy

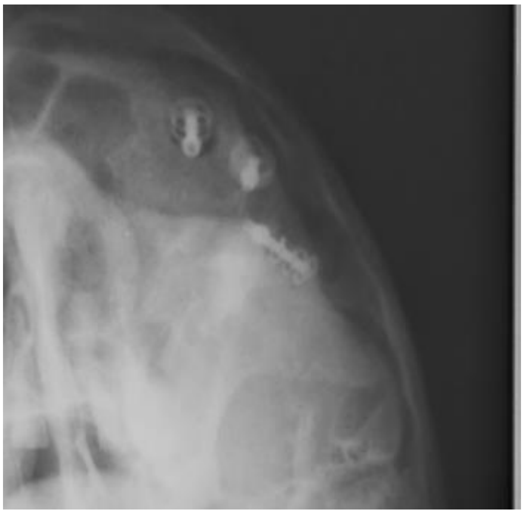

Figure 5. Waters projection radiography showing osteoradionecrosis bone damage around implant

Figure 6. Prothesis substructure remodeled for one implant retention