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A LARGE DENTIGEROUS CYST OF THE MANDIBLE – A CASE REPORT

ГОЛЕМА ФОЛИКУЛАРНА ЦИСТА ВО МАНДИБУЛАТА – ПРИКАЗ НА СЛУЧАЈ

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Abstract

Follicular (dentigerous) cysts are odontogenic cystswith developmental origin.Most commonly they develop in the region of the third molars in the mandible and the canines in the maxilla. They are usually detectedin adolescents, before the age of 30, on routine x-rays. **Aim:** The aim of this study is to present a rare case of a large follicular cyst with impacted, atopically positioned canine, in a 70 year-old patient. **Material and method:** The patient came to our clinic with a mild edema in the front region of the mandible. The ortopantomograph showed an impacted tooth in the region of the symphysis of the mandible, morphologically appearing as a canine.It also showed a large, well defined lesion with dimensions 46x28mm. A fine needle aspiration biopsy was made, confirming the diagnosis of cystisinflamata. We planned the surgical intervention considering the dimension of the cyst and the advanced resorption of the alveolar ridge in that region, so cyst enucleation with preservation of the impacted toothwas performed.The patient was evaluated clinically and radiographically on a 6 month-period of time. After a period of 12 months, when the bone defect after the cyst enucleation was reduced, theerupted canine was extracted with typical extraction. **Key words:**dentigerouscyst,enucleation, impacted tooth.

Апстракт

Фоликуларните (дентигерозни) цисти спаѓаат во групата на развојни одонтогени цисти и најчесто се развиваат околу третите мандибуларни молари и максиларните канини. Се дијагностицираат најчесто случајно, радиографски во адолесцентна и возраст до 30 години. **Цел:**Целта на оваа студија е да се прикаже редок случај на фоликуларна циста на импактиран, атопично позициониран канин кај 70 годишенпациент. **Материјал и метод:** Пациентот се јави на нашата клиника поради благ оток и нелагодност во предел на фронталната мандибула. На ортопантомографската снимка забележавме импактиран заб во пределот на симфизата со морфолошки карактеристики на канин и голема, јасно ограничена лезија со димензии 46x28mm. Во дијагностички цели, направивме аспирациона биопсија со која се потврди дијагнозата на инфламирана циста. Хируршката интервенција ја планиравме според димензијата на цистата и напреднатата ресорпција на алвеоларниот гребен во таа регија, по што беше изведена енуклеација на истата со презервација на импактираниот заб. Радиографски и клинички, пациентот беше следен на периоди на 6 месеци. По 12 месеци, кога димензиите на коскениот дефект по енуклеација на цистата беше значително намален, еруптираниот канин беше екстрахиран како типична екстракција. **Клучни зборови:** фоликуларна циста, енуклеација, импактиран заб.

Introduction

The term `cyst` is defined by Kramer in 1974 as `a pathological cavity, having fluid, hemi-fluids or gaseous contents, and which is not created by the accumulation of pus`[1]. Histologically, the cysts in the oral and maxillofacial region are consisted of fibrous capsule, which is lined with epithelium on the inside walls. Some cysts do not have an epithelium lining and the term `pseudocysts` is reserved for them.

The classification of the cysts in the oral and maxillofacial region is not an easy task, due to the big variety of cysts that seem similar to one another, but are in fact very different. Firstclassification of odontogenic tumors, jaw cysts, and associated lesions has been createdusing WHO classification from 1971, as a result of research conducted by international group of oral and other pathologists. Final classification, alongwith new knowledge, comments, and suggestions regardingprevious classification, was made and published inthe second edition of the same work, in 19922.

According to this classification, follicular cysts (a.k.a dentigerous cysts) are in fact odontogenic cysts, and they belong in the group of cysts with developmental origin. Dentigerous cyst is the most common odontogenic development cyst. It can involve any included tooth, although molars and canines are the most affected ones. Cystic formation involving the crown of premolars and incisives is rare[3].The frequency with which dentigerous cysts develop has been calculated at 1,44 in every 100 unerupted teeth, more frequent in men than in women[4].

The dentigerous cyst, by definition, is attached to the cervix of an impacted tooth. Were the toothto erupt, the dentigerous cyst would burst and cease to be a pathologic entity, as is usually the case in small eruption cysts. Small cysts are also easy to treat surgically. However, dentigerous cysts occasionally become extensive since lesions are asymptomatic even when reaching considerable size and then treatment is more difficult, as associated teeth are often impacted and displaced a considerable distance due to cyst pressure[5].

These cysts are usually discovered on routine radiographic examination, characterized by a symmetric, well-defined, usually unilocular radiolucent lesion surrounding the crown of an unerupted tooth. Generally there is a distinct, dense periphery of reactive bone (condensing osteitis) with a radiolucent center. These cysts can also manifest as multilocular entities and occasionally may be associated with resorption of the roots of adjacent erupted teeth[6]. They are rarely painful and any pain suffered is associated with infection in the lesion[4]. In some instances, these cysts can grow very large in size and can trigger the inflamma¬tion, expansion and erosion of the cortical bone[4], which is the reason for the difficulties in the treatment of these cysts.

The differential diagnosis of dentigerous cysts include odontogenic fibroma and odontogenic myxoma. Somespecimens may contain a focus of unicystic ameloblastoma and therefore require considerationof more extensive treatment[7].

Aim of the study

The aim of this study is to present a rare case of a large follicular cyst on an impacted, atopically positioned canine in a 70 year-old patient and the modality of the treatment that was used.

Materials and method

A 70 year-old man came to our Clinic complaining about a `bump` in his lower jaw. The patient had been noticing a discomfort and a strange feeling for some time, and claimed that it used to be painless. However, the last two months it started to bepainfulin that area. At this point he turned for help at his general dentist, who sent him at the Clinic of Oral Surgery at the University Clinical Center “St. Pantelejmon” for further examination.

The intraoral examination showed an edemain the vestibular region of the alveolar ridge of the right side of the mandible, in the region of 42-43, with signs of local inflammation. The patient had partial anodontia, with only residual teeth 34, 35 and 44 persisting in the mandible. Palpation of the lesion showed signs of fluctuation and it was painful for the patient.A panoramic radiograph was made (Figure 1.) and it showed a well defined, oval radiolucent lesion, clearly separated of the surrounding bone with a zone of condensed bone –a characteristic ofan odontogenic cyst. The dimensions of the cyst was approximately 46x28 mm. An impacted canine could be seen positioned vertically in the middle of the mandible.

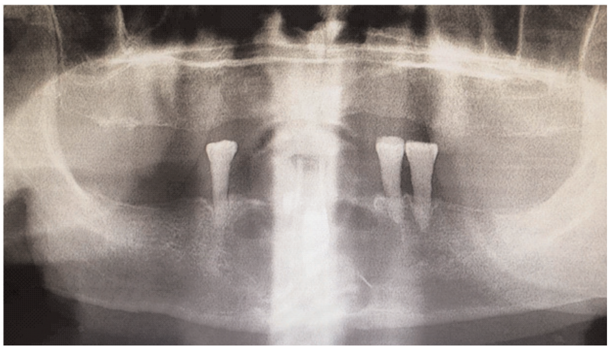

Figure 1. *Preoperative panoramic radiograph*

In the diagnostic process, as well as the treatment plan of the jaw cysts,the clinical examination of the patient and the x-ray of the lesion are not enough.In this case, regarding the age of the patient and in order to make adifferential diagnosis with other pathologic lesions, a fine needleaspirationbiopsywas made. Theradiographic findings are not a finaldiagnostic for dentigerous cysts because odontogenic keratocysts, unilocular ameloblastomas, and many other odontogenic and non-odontogenic tumours have radiographic features essentially identical to those of a dentigerous cyst[5]. Ultimately, the definitive type of the cyst can only be proven histopathologically. In every caseapostoperative histopathological verification of the removed cyst is obligatory[8].

Operative technique – The dimensions of the cyst, its association with an impacted tooth, as well as the age of the patient aredictating the modality of the treatment.

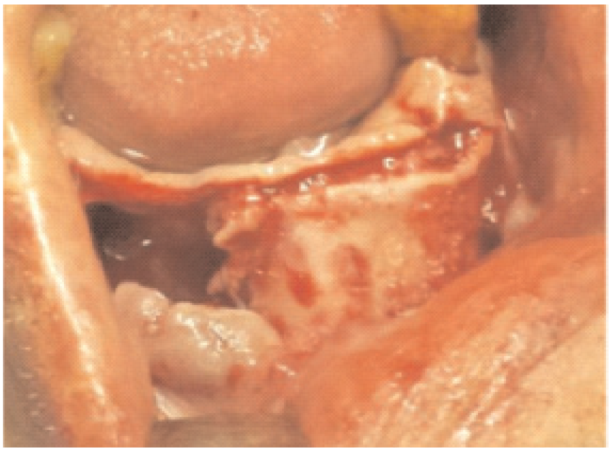

Figure 2. *Incision made along the alveolar ridge of the mandible, with two divergent relaxation incisions (reg. 44, 34) towards the base of the alveolar ridge*

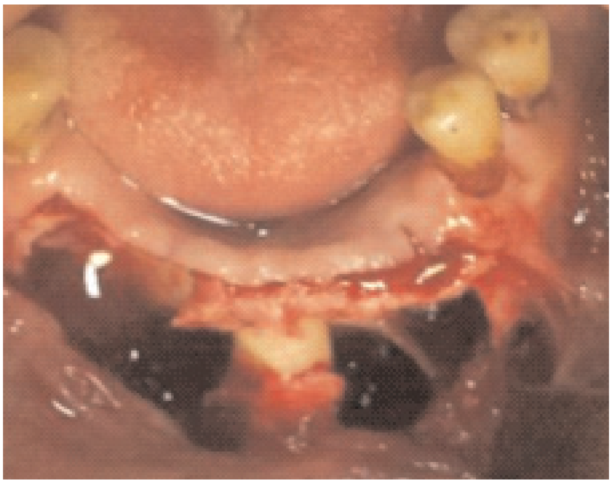

Figure 3. *The impacted canine, positioned vertically*

The patient was scheduled for removal of the cystic lesion, with preservation of the impacted tooth.

Bilateral mandibular local anesthesia was applied (Scandonest, Septodont, France), and disinfection of the oral mucosa, lips and surrounding skin wasmade.

We performed the classic flap design, with incision on the alveolar ridge between the premolars of the mandible, and two divergent vertical relaxationincisions (reg. 44, 34) (Figure 2.). After the elevation of the flap, a dehiscence of the right vestibular cortical lamina was noticed. The impacted tooth (a canine – according to its anatomo-morphological characteristics) waspositioned vertically, right in the middle of the mandible, where the lower central incisors should be (Figure 3.).

After the osteotomy and the cystic enucleation, we applied the Carnoy's solutionin the bone defect. (Figure 4.).

Consequently tothe great size of the cyst there was a great bone loss. However,the apical third of the impacted tooth wassurroundedwith bone from the vestibular and lingual lamina walls, so we decided to leavethe impacted canine in the mandible to serve as an anchor.The impacted toothis to be removed in second stage surgery, after the decreasing of the bone defect, which was divided into two separate parts, with a medial anchorage from the canine.

Due to the great defect in the oral mucosa, the wound wassutured in a way similar to the suturing technique in marsupialization –the edges of the incision were sutured in the defect of the cyst.The removed cystic lesion was sent for hystopatologicalverification.

The patient was given instruction for the postoperative care andantibiotics were prescribedfor seven days. Control check-up was scheduled for the next day. The sutures were removed ten dayslater.After the removal of the sutures, we detected a mild paresthesia on the right

Figure 4.*Carnoy's solution is applied*

Figure 5. *The situation four months after the intervention*

Picture 6. *The situation 12 months after the intervention*

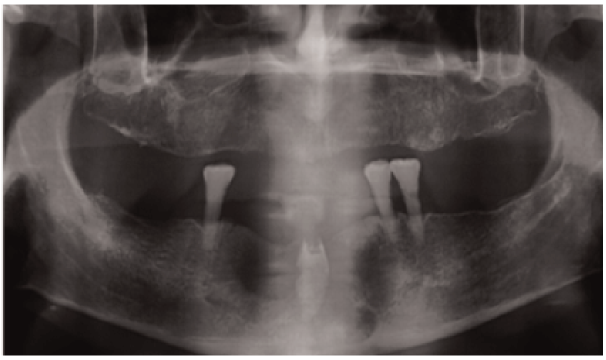

Figure 7. *A control panoramic radiograph, 12 months after the intervention*

Figure 8. *The sutures after the extraction of the canine*

side of the chin, as a result of a trauma to the mental nerve, in addition to the large postoperative bone defect.

Four months after the intervention theepithelium completely covered the formerly exposed bone. By this

Figure 9. *The situation after the removal of the sutures*

time, the paresthesia had completely stopped (Figure 5.). A control radiograph was made, showing a reduction of the size of the bone defect.

The intraoral examination 12 months after the intervention showed full consolidation of the mucosa. The formerly impacted canine was visible in the oral cavity (Figure 6.) and acontrol X-ray was made (Figure 7.). The radiograph showedreduce size of the bone defect, completely filled with newly-formed bone. The formerly impacted canine was erupted, so a typical extraction wasperformed. The wound wasfilled with Gelatamp COLTENE® (Figure 8.).The situation after the removal of the sutures is shown in Figure 9.

Discussion

The treatment of the cysts is an object of interest ever since the first description of them appeared, early in the XVII century9. The treatment options include enucleation of the cyst and extraction of the tooth or teeth embedded in (or impacted by) the cyst; or decompression and marsupialization without removal of the associated tooth. The principle of marsupialization (the Partsch I method) implies makinga fenestrationon the wall of the cyst, through which the cystic content drains into the oral cavity. This way, the pressure of the cyst is reduced, resulting in a reduction of the cystic cavity. With the procedure of enucleation (the Partsch II method), the cystic capsule is completely removedfrom the bone and the possibility of recurrence of the cyst is reduced. This method has found application in small, average and big cysts, when injury of the bordering tissues is excluded and the cyst is surrounded by bone tissue on every side10,11.

The appropriate modeof treatment must take into account several clinicalcriteria.Recently defined criteria for selecting the treatment modality (both indications and contraindications) refer to cyst size and site, patient age, the dentition involved and the involvement of vital structures12.The strategic significance of the associated impacted tooth should also be considered prior to surgery(the impacted canine was atopically positioned, and had no strategic significance for a future prosthetic). In this case a combination of the two methods for treatment of the cysts - Partsch I and II, was made. The cyst was enucleatedin toto, that refers to the Partsch II method. However, due to thegreat size of the defect, the edges of the incision were sutured in the defect of the cyst, quite similar to the Partsch I method.

Follicular cysts are asymptomatic and are usually detected on routine x-rays.They are rarely painful and any pain suffered is associated with infection4. Sometimes the cyst is removed intact, but more often the thin wall is ruptured during the surgical procedure. In an inflamed dentigerous cyst the wallmay be thickened1.

Carnoy's solution is a method of chemical curettage for the definitive treatment of odontogenic cysts. Thissolutionis consisted of 6ml ethanol, 3ml choloform, 1ml acetic acid and 1gr of ferric chloride. The solution has the ability to demark and fixate the cystic tissue. It also has a haemostatic effect, so it’s primarily used to ensure that recurrence of the cyst does not appear9.

There is evidence that vital cyst tissue releasesa potent bone-resorbing factor, thus causing great bone resorption, witch can lead to a pathological fracture1. Although such fractures may occur in any bone, their most common location in the orofacial skeleton is the mandible13.The region of the front mandibleis the least likely place for a pathological fracture to occur.In this casehowever,due to thephysiologicalatrophy of the alveolar ridge, as well as the size of the defect in the bone caused by the cyst and the size of the canine, it was quite possible.The canine was stable due to the quantity of bone surrounding his crown and apex, even though the vestibular lamina was destroyed by the cyst growth. Thatis the reason that we decided to extract the canine in the second stage, after the removal of the cyst.

Bone healing is a physiologic cascade ofevents in which complex regenerativeprocesses restore original skeletal structureand function7. This is a slow process that cantake up several months and bone remodeling last for many years.In this case, performingan augmentation of the alveolar ridge with the use of bone substituent is disputable. The use of bone graft material would make a scaffold as a base for the bone regeneration and ossification process, using osseoconducting characteristic of the bone substitute. After cystectomy, however,we can never be certain that microscopic amounts of cyst epithelium are still present in the bone defect.

Per secundam healing is prolonged and painful, so the patient was advised to take analgesics. To preventa secondary infection, as well as to ensure a proper oral hygiene and to avoid food to be trapped in the defect of the wound, we suggested an obturator to be made.Thepatient,however, refused, due to his own reasons.

Conclusion

The treatment of large cysts can be quite difficult, even the established surgical treatment options are available but there are also a great variety of criteria that should be taken intoconsideration before choosing the treatment method. According to the patient’s age, size of the cyst, location,the involvement of vital structures, we consider that this treatment was successful, with minimal surgical trauma for the patient. Periodical evaluationof the patient is to be continued.

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DENTAL CERAMIC MATERIALS, PART I: TECHNOLOGICAL DEVELOPMENT OF ALL-CERAMIC DENTAL MATERIALS

ДЕНТАЛНИ КЕРАМИЧКИ МАТЕРИЈАЛИ, ДЕЛ I: ТЕХНОЛОШКИ РАЗВОЈ НА ЦЕЛОСНО КЕРАМИЧКИТЕ МАТЕРИЈАЛИ

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Abstract

All-ceramic fixed restorations, because of their excellent aesthetic characteristics, are made more and more often. On the other hand, the discontinuity of the dental arches in the posterior regions could be solved by the restorations/bridges made out of the stabilized zirconium dioxide because of its great strength. This article reviews the current literature covering all-ceramic materials and systems. A history regarding the development of these materials is presented, starting with the first all-porcelain "jacket" crown, all the way to recently introduced all-zirconia and resin-matrix ceramic materials. The machinable materials fabricated for the CAD/CAM technology are also presented. **Keywords**:dental ceramics, CAD/CAM, glass ceramic, zirconia, hybrid ceramic.

Апстракт

Фиксните реставрации сѐ почесто се изработуваат целосно од керамички материјали поради нивните извонредни естетски карактеристики. Од друга страна пак, јачината на циркониум диоксидот овозможувапротетичко реставрирање на дисконтинуитетот во забните низи и во постериорните регии. Овој ревијален труд ги сублимира податоците од литературата кои се однесуваат на целосно керамичките материјали и системи. Во првиот дел е презентиран технолошкиот развој на овие материјали, почнувајќи од т.н. џекет коронка, па сѐ до најновите материјали, кога реставрациите целосно се изработуваат од стабилизиран циркониум диоксид или пак од керамиките со смолеста матрица. Посебен осврт е направен на материјалите за машинска - CAD/CAM обработка. **Клучни зборови**: дентална керамика, CAD/CAM, стакло керамики, циркониум диоксид, хибридни керамики.

Introduction

Contemporary fixed prosthodontics is based on using all-ceramic restorations. Impeccable esthetics and functionality offered by ceramic materials have put porcelain-fused-to-metal (PFM) system in the background[1].

For a long time the disadvantage of ceramic materials was their insufficient strength. For fabrication of crowns and bridge structures especially in the posterior region where a great masticatory load is generated (and thus possibility of breakage of the substructure), PFM systems had priority when selecting. Today, due to the qualitative development of ceramic materials, in such clinical cases, restorations can completely be ceramic made[2].

Contemporary ceramic materials "cover" all indications for fixed prosthetic rehabilitation: single tooth restorations such as veneers, inlays, onlays, crowns and posts, as well as multi-unit bridges. Zirconium posts have priority over those made of metal alloys, because all-ceramic crowns could be made with desirable esthetic effect afterwards[3]. The fabrication of veneers and crowns in the frontal region should primarily meet the priorities of esthetic and phonetic aspects; inlays, onlays and crowns in premolar and molar region should meet the requirements in terms of strength, esthetics and durability; multi-unit bridges made of ceramic material should be characterized by high strength and fracture toughness, uniform distribution of masticatory load as well as esthetics[2]. Ceramic material that is used for the fabrication of crowns over the implants should possess ability to absorb masticatory forces and to distribute pressure throughout the whole structure of the crown, to be resilient and reduce stress to the implant[4]. Technological developments in the dental industry in the field of ceramic materials provide prosthetic solution in all of the above mentioned cases.

According to Zarone et al.[5] "Since the early introduction of the porcelain jacket single crowns into the dental practice, dental ceramics have been considered among the most promising restorative materials because of noticeable prosthetic advantages: esthetic appearance, chromatic stability, biocompatibility, low plaque retention and fluids absorption, high hardness, wear resistance, low thermal conductivity, and chemical inertness". An ideal all-ceramic material should possess excellent esthetic characteristics, including translucency, light transmission, and natural tooth color, and, at the same time, optimal mechanical properties such as high flexural strength and fracture toughness, as well as limitation of crack propagation that may occur in terms of the functional and parafunctional load conditions; all these features are important for the longevity and reliability of all-ceramic restorations[5].

However, despite the large number of all-ceramic materials for clinical use, the analysis of Conrad et al.[6] showed that there is still no universal material or system that could be used in each clinical situation. The successful use of various ceramic systems depends entirely on the clinician's ability to propose an appropriate treatment plan for each patient individually, to select an appropriate ceramic material and manufacturing technique and to choose appropriate luting material and procedure[6]. But, whether ceramic restoration will meet the expectations of the patient and the dentist depends on the dental technician's knowledge, skill, creativity and dedication[7].

This paper reviews the current literature covering all-ceramic materials and systems, with a overview of the technological qualitative development of these materials, starting with the first all-porcelain "jacket" crown, all the way to recently introduced all-zirconia and resin-matrix ceramic materials.

Technological development of dental ceramics

The usage of ceramic materials in dentistry dates back as far as 1889 when Charles H. Land patented the first all-porcelain "jacket" crown – PJC[8]. It was so-called, as this restoration rebuilds the missing tooth structures with porcelain covering as a jacket. This kind of restoration was extensively used (until the 1950s) after improvements made by E.B. Spaulding[9].

The failure rate of the "jacket" crowns, which was very high because of the internal micro-cracks that appeared during the cooling phase of fabrication, resulted in the development of the porcelain-fused-to-metal (PFM) system innovated by Abraham Weinstein in the late 1950s[10]. Despite the good reliability that this system has, the appearance of PFM restorations doesn't fulfill the patients' high esthetic demands.

First successful attempt to strengthen the feldspathic porcelain was made by W. Mc Lean and T.H. Hughes in 1965. They reinforced dental feldspathic porcelain with an addition of up to 50% aluminium oxide powder during the manufacturing[11]. Although it had twice the strength of the traditional PJC, it could've been used in the anterior region only (due to its lower strength). Its higher opacity was also a major drawback[12].

Another development in the 1950s by Corning Glass Works led to the creation of the castable Dicor® crown system in which the glass was strengthened with various forms of mica. A glass restoration (using the lost-wax casting technique) underwent through the "ceramming" process that provided a controlled crystallization of the glass. Such glass ceramics, had different crystalline formations depended on the feldspathic formulation used, such as leucite, fluoromica glass, lithium disilicate, and apatite[13]. Numerous small crystals that were evenly distributed into the glassy matrix increased the strength and toughness of the ceramic. The processing difficulties (time and temperature controlling) and high incidence of fracture were factors that led to the abandonment of this system[14].

The idea for the first pressable ceramic was primarily developed at the University of Zürich, Zürich, Switzerland, in 1983. Later on (1986), Ivoclar Vivadent took over the development project and after some improvements that have been made, in 1990 the IPS Empress system was introduced[15]. IPS Empress® 1 was high leucite-containing ceramic in which the leucite crystals, incorporated in the material, increased the coefficient of thermal expansion. The leucite crystals improved flexural strength and fracture resistance through so-called dispersion strengthening, slowing down the micro-crack propagation that easily could happen into the feldspathic porcelain. This process of pressing the heated ceramic ingots became very popular due to the good esthetics and easy usage in the laboratory.

Later on, Ivoclar Vivadent introduced the second generation of heat-pressed dental ceramic material, IPS

Empress® 2, containing about 65 vol % lithium disilicate, which strength was more than twice than that of first generation – the leucite-reinforced IPS Empress® 1. In late '90s, IPS Empress 2 contained 70 vol% lithium disilicate that made material suitable for production not only a single unit restorations but for the 3 unit FPD in the frontal region as well. A 5-year clinical study revealed a 70% success rate when used as a fixed partial denture framework[16].

Since 2004, Ivoclar Vivadent's leucite-based and lithium disilicate ceramic materials for heat-pressed technique are fabricated as IPS Empress Esthetic and IPS e.max Press respectively.

In 1983, Matts Andersson in cooperation with Nobel Biocare developed the Procera method for high-precision industrial manufacturing of dental crowns. In 1989, the first ceramic computer-aided designed and computer-aided manufactured (CAD/CAM) coping, the Procera® AllCeram, was introduced. The Procera® AllCeram crown consisted of a densely sintered alumina core that contained more than 99.9% aluminum oxide to which feldspathic porcelain was fired as a veneering material[17].

When VITA In-Ceram was introduced to the dental market in 1989, a new era of all-ceramic restorations has begun. The slip-casting technique developed by Sadoun allowed the production of restorations with an excellent long-term prognosis including a three-unit anterior bridge without metal substructure[18]. The aluminum oxide content of In-Ceram® Alumina has been increased to 80% and, by using the infiltration technique with special lanthanum glass (12% La_2O_3, 4.5% SiO_2), a flexural strength value of approximately 500 MPa was reached for the first time. By using industrially sintered, highly homogeneous aluminum oxide blocks for the CELAY system in 1993 and for the CEREC system in 1997, In-Ceram® Alumina BLANKS gained increased strength and excellent machine processability. In 1994, VITA introduced In-Ceram® Spinel ($MgAl_2O_4$) with better translucency and esthetics, but lower flexural strength of 250–400 MPa. In-Ceram® Zirconia is considered as a modification of In-Ceram® Alumina, in which, for the first time, zirconium oxide was used as in a dental ceramic. Alumina core was strengthened with 33 wt.% of 12 mol% cerium-partially stabilized zirconium oxide, which increased the flexural strength to 620–700 MPa19. Until then, many problems regarding stability of zirconia used as biomedical material have been already solved.

Since 1969, zirconia has been considered as a material for production of surgical implants[20]. In 1985, yttria-stabilized zirconia was used for the first time to replace femoral heads in the hip joint arthroplasy[21]. Between 2000 and 2002, a series of premature failures (fractures)of ceramic heads made of Y-TZP in such prostheses were reported[22,23], that resulted in reduced use of zirconia in orthopedic surgery by more than 90%[24]. The reason for such fractures was changed processing procedure during the production, which resulted in increased monoclinic content[23,25]. These episodes increased awareness of phase transformation of a zirconia used as biomaterial and imposed caution during processing of the material and production of prosthesis.

In 2001, the Cercon all-ceramic CAM system was introduced, using for the first time dental zirconia for the production of crowns and bridges. Two years later, colored Cercon bases were introduced, offering not only a material with high flexural strength but a material with natural, tooth-like shades that meets aesthetic demands[26].

In the last 20 years, most of the ceramic manufacturers have started a production of an already established and proven all-ceramic materials, as milling blocks for a CAD/CAM fabrication, but with improved chemical composition and mechanical features. The first commercially available all-ceramic CAD/CAM material was VITABLOCS Mark I (1985), feldspar ceramic that in 1991 was replaced by Mark II. Ivoclar Vivadent's leucite-reinforced and lithium disilicate ceramics (known as IPS Empress Esthetic and IPS e.max Pressfor heat-press technique) were introduced (2006) as IPS Empress CAD and IPS e.max CAD respectively. As a replacement for the glass infiltrated Vita In-Ceram® Alumina and Vita In-Ceram® Zirconia, VITAZahnfabrik offered densely sintered alumina and zirconia CAD/CAM blocks -In-Ceram® Al and In-Ceram® YZ.

The use of CAD/CAM technology spurred a whole new generation of zirconium dioxide-based materials used for manufacturing of substructures with superior mechanical properties. They are characterized with sufficient flexural strength of 900 MPa to 1300 MPa, allowing to be used for fabrication of multi-unit posterior bridges. Final esthetic appearance of the restorations is achieved by veneering the substructure with feldspar porcelain.

Several manufacturers introduced crown- and bridge-frameworks (Lava, 3M ESPE; Procera Forte, Nobel Biocare; Vita In-Ceram YZ, VITA; and Cercon, DENTSPLY) milled from blocks of pre-sintered yttrium-stabilized zirconium dioxide ceramic. The oversized milled frameworks are then sintered (with shrinking of the structure by 20–25%) providing an excellent fit[27]. Other manufacturers mill fully sintered zirconium dioxide blocks(Everest, KaVo; DC-Zirkon and DC-Zirkon col., DCS Bien-Air Dental), known as HIP-ed (hot isostatic pressing) zirconia, to avoid the shrinkage factor, thus providing a superior marginal fit[28]. However, there are several undesirable effects in milling dense sintered ceramic blanks: possibility of unwanted surface and structural defects in the ceramic restoration that minimize overall restoration strength and reliability, longer milling time and increased wear of the milling tools[29].

Further improvements in the composition and chroma features, led to introduction of a new era of zirconia materials that can be used for production of all-zirconia restorations without need of veneering, thus preventing failures due to porcelain chipping[30]. At the same time, these materials are found to have less abrasive effect to enamel of the opposite dentition compared to veneering porcelain and a pressed glass ceramic[31] or even natural enamel[32]: Lava™ Plus HT Zirconia (2012) of 3M ESPE, Zenostar® Full Contour Zirconia (2013) inovated in close cooperation between Wieland Dental and Ivoclar Vivadent, as well as Dentsply's Cercon® ht True Color (2015), zirconia discs with 16 different shades[26].

In collaboration with Fraunhofer Institute for Silicate Research ISC, Dentsply and VITA have used a new lithium compound to create a glass ceramic with higher flexural strength than lithium disilicate ceramic. After breaking up the partnership, Dentsplyand VITA continued with their own research which resulted in the introduction of zirconia-reinforced lithium silicate ceramics - Celtra Duo and VITA Suprinity® (2013).

Humans' striving to mimic the features of the human tissues has led to the creation of a new type of dental materials, so-called 'hybrid' ceramics. In 2011, 3M ESPE have introduced the first 'resin nano ceramic', Lava™ Ultimate CAD/CAM Restorative, which consists of a ceramic particles with nano-dimensions incorporated into the resin matrix.

Taking into consideration specific structure and composition of the dentin and spongy bone that consist of inorganic and organic interconnected phases, the development of hybrid materials took another direction. The inorganic constituents of biological tissues are weak by themselves, but together with the organic matrix and specific structural distribution, materials with superior mechanical properties are built [33].

The idea for developing the novel kind of interpenetrating phase material was discussed by Dr. Norbert Thiel (VITA Zahnfabrik) and Prof. Russell Giordano (Boston University) 20 years ago. Finally, in 2013, VITA has introduced VITA Enamic®, retaining the ceramic structure of Mark II and adding a polymer. A porous feldspar glass ceramic was infiltrated with a polymer that closes the gaps between already existing ceramic material. In this way, VITA Enamic® imitates the properties of dentin, with respect to the elastic modulus and density[34].

These are the first attempts, ceramic materials to get features similar to the human enamel and dentin in terms of wear characteristics and modulus of elasticity and yet to have properties as those of glass ceramics, i.e. similar optical features, flexural strength and fracture resistance in order to withstand the masticatory load[4].

The newest one, Cerasmart™ from GC, introduced in 2014 features the highest flexural strength (in this category of hybrid materials) of 230 MPa, and in the same time offers a high flexibility (breaking energy) of 2.2 N/cm to buffer the masticatory pressure[35].

Conclusion

Starting from the first "jacket" crown, all the way to the newest ceramic materials, the fast and versatile technological development of the dental industry, in this field, is easily noticeable.

Glass ceramics, because of their optical characteristics, are still considered the best material when it comes to esthetics. The stabilized zirconia, as a material with astounding mechanical characteristics and strength, is used for the production of dental bridges, as a replacement for the metal substructure. Biomimetics, as a science with a very fast development rate, resulted in the innovation of the hybrid ceramics, which come closer and closer to the human tissues.

In the future, perfecting the development is expected not only for the technological processing, but for the ceramic materials as well, with maximizing their potential abilities, while minimizing their weaknesses.

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ANALYSIS OF THE DISTRIBUTION OF OCCLUSAL VERTICAL STRESS IN CANTILEVER DENTAL BRIDGES - METHOD OF FINITE ELEMENTS: A LITERATURE REVIEW

АНАЛИЗА НА ДИСТРИБУЦИЈАТА НА ОКЛУЗАЛНИТЕ ВЕРТИКАЛНИ СИЛИ КАЈ ДИСТАЛНО ПРОДОЛЖЕНИ МОСТОВНИ КОНСТРУКЦИИ–МЕТОД НА КОНЕЧНИ ЕЛЕМЕНТИ: РЕВИЈАЛЕН ТРУД

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Abstract

Cantilever dental bridges are prosthetic appliances which have abutments and distally positioned pontic. In cantileversdental bridges, occlusal forces which transfer via the distal cantilever cause changes in the dentures and teeth in terms of rotation and bending, depending on the direction and of the stress and the amount of the load. Distribution of occlusal load is an important factor for the treatment's effectiveness and its prophylactic influence on the remaining teeth. In line with this, the present paper will look at various authors who have researched the area of occlusal stress and its distribution in cantilever dental bridges. **Keywords:** Cantilever, Finite element method, Fixed partial denture, Occlusal forces, Prosthetic restoration, Shortened dental arch.

Апстракт

Дистално продолжените мостовни конструкции се протетички изработки кои имаат носачизабии висечки членови кои се поставени дистално од носачите . Кај дистално продолжените мостовни конструкции, оклузалнате сили кои се пренесуваат преку продолжените членови предизвикуваат придвижувања на конструкцијата и забитево смисол на ротација и инклинација зависно од правецот на дејствување и јачината на силата на оптоварување. Дистрибуцијата на оклузалните сили врз забите носачи е значаен фактор за ефектот од третманот и неговото профилактичко делување врз преостанатите заби. Од тој аспект во трудот ќе биде направен преглед од автори кои се бавеле во подрачјето на оклузалните сили и нивна дистрибуцијата кај дистално продолжените мостовни конструкции. **Клучни зборови:** Дисталенчлен, метод на конечни елементи, дентален мост, оклузални сили, протетичка реставрација, скратен дентален низ.

Introduction

Partial tooth loss leads to morphological, functional, and aesthetic disturbance in the functions of the masticatory system. Therapeutic means to compensate for partial tooth loss are mobile appliances, bridges, or a combination of the two. A dental bridge is a fixed prosthetic appliance used for masticatory, phonetic, aesthetic and prophylactic therapy and restoration of the masticatory system.

Planning of dental bridge appliance includes two basic elements: biological and mechanical. The biological aspect refers to the mechanism of transfer of masticatory force that is exclusively dental, regardless of whether the bridges are fixed or mobile. The mechanical aspect refers to the way bridges are connected and fixed to the abutment teeth. The pontics or the body of the bridge may be inserted between the abutment teeth (traditional bridge) or extended distally or mesially (cantilever bridge). Cantilever bridges are defined as fixed restorations that have one or more abutments on one end, while the other end is left unsupported.

The pontics in a cantilever dental bridge may be positioned either mesially of the abutment tooth or distally of the abutment tooth. Distally cantilever dental bridges are indicated for patients with a shortened dental arch.

Aim

The purpose of this paper is to analyse the findings on the distribution of occlusal forces in distally cantilever bridges.

Material and method

The material consists of 315 papers that examine distally cantilever dental bridges. The paper looks at 38 papers where the abutments are natural teeth. The papers were acquired by means of international journals and PubMed and EBSCO database research done from January, 2005 to January, 2016. Research was done using keywords according to the Mesh index.

Discussion

The traditional goal of dental treatments is maintaining dental arches with presence of 28 teeth. According to data gathered from the first phase of the NHANES III research (Third National Health and Nutrition Examination Survey), completed in the USA from 1988-1991, the average number of teeth per capita was 23,5, while the goal set by the WHO is preserving at least 20 teeth until the age of 80.[4]

Distal cantilever dental bridges require more attention compared to conventional ones. However, if the biological and mechanical aspects of the cantilever dental bridge are well balanced, it is very likely that it is going to be successful.[5]

One of the elements that speak of the success rate of this treatment is the life span of these bridge appliances. According to Sailer, the duration of dental bridge prostheses is defined as the time frame of the experiment during which a maximum of two interventions have been made.[6]

The classifications of bilateral and unilateral partial tooth loss do not define the number of lost teeth. This is why Witter and his associates made additional classification of the distal tooth loss by distinguishing four categories of shortened dental arches: 1. Slightly shortened dental arches; 2. Moderately shortened dental arches; 3. Extremely shortened dental arches; and 4. asymmetrical extremely shortened dental arches. According to them, decision-making on extending a shortened dental arch should be based on the principle of: examination of the masticatory system function, treatments value for the patient, oral function and the patient's perceived impact on oral health-related quality of life, as well as on the type of shortened tooth arch. Witter and his associates believe that slightly shortened dental arches should not be extended, while extending moderately shortened dental arches is indicated in exceptional cases, especially for aesthetic reasons. In the case of extremely shortened dental arches and asymmetrical shortened dental arches, they believe that there are sufficient reasons for extension.[7,8]

Anneloes and associates made a clinical trial on patients with shortened tooth arches with 3-4 lateral teeth missing. The patients were monitored for 27,4 (± 7,1) years, and it was found that in 20 out of 23 participants the condition remained unchanged.[9]

The concept of shortened dental arches implies that shortened dental arches with at least 4 occluding pairs, preferably in symmetrical positions, are sufficiently capable to maintain satisfactory oral function.[10]

Wolfart analysed the quality of oral health via the HRQoL index in two separate groups of participants. The first group had shortened dental arches with lost molars and dental bridges that did not replace the lost molars, while the second group had shortened tooth arches and a mobile prosthesis which replaced the lost molars. The values generated with the HRQoL index did not show any significant differences between the groups. This led him to the conclusion that there is no need to replace missing molars.[11]

According to Fueki, the concept of shortened dental arches is based on indirect evidence and it is not in contradiction with current occlusion theories. He claims that this concept is not suitable for patients aging up to 50, those with malocclusion Angle III, Kenedy class III, patients with verified parafunction and symptoms in TMJ and a significantly decreased periodontal support of remaining teeth.[5]

Aras and associates during the 1-year research examined: mastication, occlusal forces, and occlusal contact in patients with shortened dental arches Kennedy I class. The research covered three groups of 10 patients each. The first group included patients with shortened dental arch (natural teeth or bridge appliances), the second group was made up of patients with mobile partial prostheses, while the third group was a control group of patients with fully natural dentition. No significant difference was noticed between the groups with shortened dental arches with or without prostheses in the masticatory effect, however, in patients with shortened dental arches, a significantly lower instance of contact and weaker forces were noticed compared to patients with entirely natural dental arches (P <0,05).[12]

Witter monitored 74 patients with shortened dental arches and 72 with full dental arches. Following a 9-year research, Witter came to a conclusion that there was no difference between the two groups as far as the masticatory system was concerned.[13]

Two independent research studies on accepting the concept of shortened dental arches were carried out in Victoria, Australia and Great Britain. The findings were contradictory. In Victoria, Australia, 61% of the interviewees accepted the concept of a shortened dental arch, while in Great Britain, only 1.4% accepted it.[14, 15]

Prosthetic therapy is often necessary to restore the function and aesthetics in patients with advanced stage of periodontal changes. Remaining teeth are usually mobile and need to be immobilized and periodontally treated. According to the perio-prosthetic treatment first introduced in Sweden in 1970, circular fixed bridges can provide certain rigidity and a more favourable distribution of masticatory forces on all remaining teeth. This concept is in collision with Ante's rule, however, but authors justify their claim by pointing out that Ante's rule is more focused on the number of teeth. Furthermore, several multiyear research studies have shown that circular fixed bridges can be successfully supported by a minimal number of teeth if teeth are well positioned, the condition of the periodontium is under control and has kept 20-30% of the original periodontal supporting tissue.[16, 17]

Maximal force measurement of masticatory pressure is a useful indicator of the functional condition of the masticatory system. The values of this force vary depending on the measuring method, sex, and age. Still, it is of great use that the results can be compared to corresponding referential values. The masticatory force is a result of a combined action of the masticatory muscles, the biodynamics of the lower jaw and the reflex mechanisms.[18]

Bonakdarchian and associates found that the average maximal masticatory forces in adults with normal occlusion are significantly higher in male patients compared to female ones.[19]

Pain is an important factor for controlling the scale of masticatory force. Furthermore, this factor can also be used to treat some irregularities and painful conditions of the masticatory system.[18]

Johnsen and associates looked at the intensity of masticatory forces in each tooth separately in patients when under anesthetics and without. They noticed that the force is higher when teeth are anesthetized, i.e. when the periodontal sensitivity is off. Likewise, they noticed that the masticatory forces are higher distally.[20]

Fratila and associates used photoelastic analysis to look at the distribution of occlusal stress in a conventional bridge with two abutments and a pontic in between, while the other was a mesial cantilever with two units, an abutment, and a pontic. The loading was vertical on the occlusal surface. In a classical bridge, when the distal abutment was loaded, the highest strain was noticed around the connection of the distal abutment and the pontics, as well as on the distal abutment's periodontal tissue. A significantly smaller stress was distributed via the pontic to the mesial abutment. The same, only in the opposite direction, occurred when the mesial abutment was loaded. When the middle part of the pontic was loaded, an approximately symmetrical distribution of stress, however a much smaller stress was registered in the periodontal tissue of the mesial abutment. The authors explain this in relation to the number of roots, since the distal abutment has two roots, while the mesial only one. Almost identical findings on the distribution of stress in conventional bridges were reported by Motta and associates.[21, 22]

In mesial cantilever dental bridges with two units, when the abutment was loaded, most stress was distributed onto the root of the tooth. When loading was on the mesial extended unit, the greatest deforming stress occurred on the connection of the abutment and extended unit and on the apical mesial surface of the root and the mesial wall of the alveolar bone. The distal root recorded low values of distributed stress, with an occurrence of the 'pulling' phenomenon. Overall, there is strong and uneven loading of the abutment and the bone structures, and the restoration has a tendency to tilt mesially. Identical results were obtained by Eraslan and associates.[21,23]

Planning a bridge construction must provide an optimal secure static, stability to withstand masticatory stress and to preserve the integrity of supporting tissue. Crucial to this is familiarity with the features of biological and mechanical elements of a bridge.[24]

The stress forces generated in cantilever dental bridges are generally higher than in conventional dental bridges, due to the physical principles arising from the fact that the pontic is acting as a single lever.[25]

To minimize the risk of a single lever effect, Jeong recommends decreasing the occlusal surface of the extension and the occlusal contacts, as well as remove contact in lateral movements.[26]

According to Fratila, the stress loaded on partial dentures may cause: luxation, inclination, rotation and bending. This may be compensated by static and biodynamic balanced planning of construction. Cantilever dental bridges with one or more pontics have one point of reliance and therefore can be moved in all directions, so they cannot be in dynamic equilibrium. It is therefore necessary for each bridge construction with a distally canivelr to have at least two abutments.[21]

For cantilever dental bridge constructions, Milas recommends a balanced occlusion with absolutely no interferences.[27]

Edward lists three crucial factors in planning distally cantilever bridges: abutments, functional masticatory strain, and connection abutment and extension. The abutments need to have a periodontal surface which is larger than the tooth which is going to be replaced, the ratio of the coronary and radicular part of the abutment should be 2:3, small motility, be vital, and have a healthy periodontium. Occlusal contact should be diminished; occlusal surface of the cantileverpontic should not be in contact with its antagonists.[28]

Eraslan analyzed on models the influence of the length of a distal cantilever of the bridge construction, the strain distribution on bridge constructions made by metal-ceramic and all-ceramic materials. The research showed that by increasing the length of the cantilever,the values of the deformation forces increase proportionally.[23]

Tomás Geremia also got similar results which showed that increasing the length of the cantileverfrom 10 to 20 mm resulted in a rise of the axial force of approximately 50% and about 70% rise of the sagittal force.[29]

The fact that the length of the cantileverplays an important role in the deforming strain distribution is confirmed in the research work of Bevilacqua and Rubo and associates.[30,31]

Using the method of finite elements analysis, Maia Correia and associates looked at the deforming strain distribution on the cantilever and found that if 50N were loaded on an abutment (average value of masticatory stress), deforming strain will decrease and will reach Titanium's elasticity resistance threshold if the connector is made in oval shape with a vertical radius of 1,68 mm and a horizontal radius of 1mm.[32,33]

Manda and associates researched the effect of increasing the vertical dimension on the maximum stress developed within the connector of the cantileverdental bridge during maximal load of a cross-arch dental bridge with a 1- and 2-unit cantilever.The researched connections were of 3, 4, and 5 mm. The increase of the vertical dimension of the distal connection to the retaining abutment, for each FDP, presented a maximum stress value decrease of approximately 25% when the height of the connection was increased from 3 to 4 mm, and 48% when the height of the connector was increased from 3 to 5 mm. For the 2-unit cantilever restoration, the stress decreases were approximately 10% for the 4-mm connector. The highest stress value was measured on the 3-mm connector.[34]

The design of the denture is especially significant for the distribution of masticatory stress on supporting tissues. Designing a connector located in specific conditions must satisfy biological and aesthetic needs, especially in the posterior region where the stress is much higher and clinical crowns shorter.[23,32,35]

Romeed states that a 3-unit denture is a better solution than the 2-unit one.[36]

Guo and associates analysed the stress distribution in the abutment periodontal ligament of posterior cantilever bridge under transient dynamic loads using a three-dimensional finite element model. A cantilever bridge was examined using second premolar and first molar and distally extended second molar. The loads were set as 250 N occlusal forces loaded at different positions on the cantilever. It was found that with the increase of loading, the stress value in the abutment periodontal ligament increased gradually. When the load was on the second molar, tensile forces appeared in the mesial part of the second premolar.[37]

Two types of bridge constructions were researched in Korea: bridge constructions with no extensions and unilateral or bilateral distal cantilevers.

39 Korean patients were provided with 50 bridge constructions that had between 11 and 14 units with an average of 5 to 7 abutments and a total periodontal ligament area of 79% of the total ligament area of the replaced teeth, meaning abutment teeth had average 26% preserved periodont. Inthe 3-year follow-up examination, the bridge constructions were stable in all patients who generally maintained good oral hygiene. The change in the periodontal ligament area over the 3-year observation period was negligible (1 mm2 per dental unit) and showed no statistically significant difference in relation to the three types of bridge constructions.[38]

There are many more data in the relevant literature, however, the greatest challenge is the different methodology of research used which makes results difficult to compare. There are very few clinical trials, and the ones published mostly refer to periodical analyses.

Conclusion

Most research papers recommend that cantilevers should have at least two abutments, while the extension should have smaller occlusal surface compared to the replaced tooth and a minimal number of occlusal contacts.

Results on the masticatory stress distribution show that strongest strain occurs on the connectors of the distal cantilever and the mesial abutments.

The largest part of relevant research was performed on models, however, clinical trials with periodical patient monitoring complementthem, in most cases, and help provide useful recommendations for the clinical practice.

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