BIOMECHANICAL RESEARCHES REGARDING THE OPTIMISATION OF TEMPOROMANDIBULAR JOINT ENDOPROSTHESIS IN PATIENTS WITH COMPLICATIONS OF PROSTHETICAL APPROACH REHABILITATION AND SDSS (DISFUNCTIONAL SYNDROME OF STOMATOGNATHIC SYSTEM) TREATMENT - LITERATURE REVIEW-

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ABSTRACT

Temporomandibular joint (TMJ) reconstruction may be required, in complex cases, in which coexist TMJ complex disorders, with mandibular or zygomatic arch defects. The reconstructive TMJ options include autogenous tissue, alloplastic material, or combinations of these. The prosthetic components were designed to restore major defects in the zygomatic arch and the mandibular ramus and body. Development of new alloplastic implants, that provide, long-term rigid fixation by the process of osseointegration has led to a renewed interest in the application of mandibular plates for the TMJ rehabilitation of patients with these complex type of dysfunction .

Keywords: temporomandibular joint ,endoprosthesis,disfunctional syndrome of stomatognathic system, treatment, rehabilitation ,TMJ,biomaterials.

INTRODUCTION

TMD is a heterogeneous groups of clinically important dysfunctions and pathologies involving the TMJ, the associated jaw muscles,or both. The specific symptoms including painful or pain-free joint sounds, reduced range of motion, and joint and/or muscular pain that occur disproportionally between sexes, are observed in a higher incidence in females than in males. [1,2] Importantly, up to 70% of TMD patients suffer from an abnormal position of the TMJ disc during function, which is often referred to as internal derangement. The management options for TMD are variable according to the severity of the disease. Non-invasive and minimally invasive treatments are preferred for patients in early stages of TMD while the more invasive approaches are reserved for advanced stages of the disease. Unfortunately, no treatment

consistently offers permanent recovery, and many patents require repeat therapy or follow-up surgeries.
In our country, the therapeutic arsenal solution by endoprosthesis of temporomandibular joint is performed in oral-maxillofacial surgery clinics of great academic , centres by means of employing import prostheses that most often the middle social person can't afford.
In this context, the research upon bio-mechanical processes taking place in joints rebuilt with in vitro prostheses, along with the submission of new constructive solutions and endo-prosthetic biomaterials, constitutes a priority for recovery medical bioengineering. [3,4]
If we can refer to the typology of these of prostheses depending on the ***structures*** , they are successfully trying to replace, prosthetic devices can be differentiated into fossa-eminence prostheses, ramus prostheses and condylar reconstruction plates, and total joint prostheses. Fossa and total joint prostheses are recommended when the glenoid fossa is exposed due to excessive stress (degenerative disorders, arthritis, ankylosis, multiply operated pain patients). Singular replacement of the condyle is preferred as a temporary solution in ablative surgery.
The use of prosthetic devices for long-term replacement should be restricted to selected cases, taking care to retain the disk, in order to prevent penetration into the middle cranial fossa. The term '*condylar reconstruction plate'* reflects this more clearly than 'ramus prosthesis' which suggests permanent reconstruction. Long-term studies comparing the functional and aesthetic results of the various prostheses and condylar reconstruction plates are not available, which leaves the choice to personal experience,said literature by O.Driemel in 2009.**[5]**

The temporomandibular joint represents a complex sensible joint, with a high degree of mobility and statistically revealed that millions of persons develop temporomandibular dysfunctions.
Treatment options for joint pathology must be carefully analysed in order to evaluate the eventual optimisations, in order to introduce new techniques. When joint dysfunctions are severe (the suppression of joint mobility) joint reconstruction with partial or total prostheses is essential necessary.

The temporomandibular joint creates the link between the mandible and the cranial skeleton and regulates mandible's movement and it is a bi-condylar joint, in which the condyles, places at the extremities of the mandible, function simultaneously. The mobile upper rounded ending of inferior maxillary is termed condyle, and the socket is called articular fossa. Between the condyle and the fossa there is a disc of fibrocartilagenous tissue, that acts as a buffer that absorbs the strain and allows the facile movement of the condyle in opening and closing the oral cavity.[6]
The feature and the specificity,of temporomandibular joint physiology speaking , differentiating this joint from all the other, is constituted by its articular surfaces, covered by fibrocartilagenous tissue, instead of hyaline cartilage. Articular surfaces have a concave shape (the articular fossa), convex shape (the condylar head, an anterior eminence). The components of the joint are held together by various kind of connection ligaments. These ligaments completely surround the joint, creating the articular capsule. Between the articular surfaces there is a fibrocartilagenous disk. The disk divides the articular cavity in two compartments (upper and lower).

The synovial liquid flowing through these compartments provides a lubrication role, but also a nutritional one, for joint's structures. The disk distributes the strains of the joint on larger areas, lessening the pressure in the joint and, as

such, the wear of condylar head and articular fossa.[7]
The movements of temporomandibular joint are complex, the joint presenting three main movements: lateral rotation, anterior-posterior translation, and medial-lateral translation; these movements are combined during the masticatory process. The muscles responsible for these movements are: temporal, masseter and pterygoid muscle.[8]
Following the nuclear magnetic resonance(MRI), it has been established that the spectrum of temporomandibular joint pathology may vary; the dissemination of the cause that produces pains and dysfunctions supposes relevant knowledge regarding the anatomy, physiology and pathology of this region. The abnormal positions and the functional relation between condyle, meniscus and glenoid cavity are known as internal disturbances. [9,10]

The temporomandibular dysfunction (TMD) is a generic term used for any problem associated with maxillary joint. Possible causes are: clenching or grinding (bruxism); these are processes that subject the joint to high strains); disk displacement; the presence of osteoarthritis or rheumatoid arthritis; the strain that could determine a person to tighten the facial and maxillary muscles, or the clench his/her teeth; advanced age. The most frequent joint dysfunctions are pain dysfunction syndrome, internal derangement, arthritis and trauma.[11,12]
Coordinated movement of condyle and disk is essential for maintaining disk integrity. The meniscus is a fibrocartilaginous structure responsible for shock absorption, load transmission, and stability. The displacement of the disk is the most prevalent cause of arthropathy of temporomandibular joint. As the disk force compulsively deviates from the normal position, the direct contact between fossa and condyle is the one that creates shearing strains in the cartilaginous underlayer, and determines joint surface wear, pain and the suppression of joint function.[13] Anterior displacement of the disk envelopes different degrees of severity- and literature confirm throught , Wilkes, who elaborated -the stage classifications for disk derangements. These stages were defined based on clinical or radiological findings or based on the anatomic pathology of the maxilla. It has been suggested that disk displacement determines the alteration of strain distribution in the disk and the heightening of friction coefficients between the articular surfaces, with secondary affectation pf the tissue as a result and the internal derangement often precedes the debut of the osteoarthritis.[14]
The biochemical composition of the intraarticular meniscus is represented by water, fibrillar proteins, proteoglycans, and adhesion glycoproteins .The middle of the meniscus contains: 0.14% (00.8) dry matter, 0.96% (0.39) glycosaminoglycans and collagen 68.2% (14.5). There are no significant differences from base to tip but, from anterior to posterior, low concentrations of glycosaminoglycans were in the posterior area and the highest concentration of collagen in the intermediate area. The concentration of componnents are higher in the middle area than in the side of the disc.Thus, tissue engineering could promote traumatic lesions of the temporo-mandibular meniscus. [15]

It has been also,proved that different types of functional malocclusion are partially responsible for the signs and the symptoms of articular dysfunctions. The posture of the body during sleeping is also presumed to be one of the possible reasons for disk displacement.
A study conducted by Hibi and Ueda suggest that a defective posture allows the condyle to move in posterior direction, and this posterior movement determines the anterior displacement of the disk. It has been reported that another risk factor for

temporomandibular joint is constituted by chronic juvenile arthritis, a chronic arthritis during childhood, with a debut before the age of 16, and a period of action of more than three months.[16]

The treatment algorithm for temporomandibular joint dysfunction (TMD) begins with conservative non-surgical therapies, the surgery being the last resort. Most of the patients with temporomandibular joint illnesses can be successfully treated by non-surgical therapies, and surgical interventions are needed only for a small percentage of the population. Before assuming invasive methods for treatment management, we must exhaust all the non-surgical options of treatment. The right course of action may vary, for example: medication, therapy, splints, arthrocentesis, discectomy or prosthesis.[17] The lack of treatment for unilateral articular dysfunctions determines a facial asymmetry, and the researchers have proven that bilateral derangements at this level may induce mandibular retrognation (displacement of the mandible towards the posterior region), especially if this derangement takes place during childhood or adolescence, the peak being represented by the pubertal period conclude literature by Isberg and coworkers,in 1998.[18-21]
Discectomy, the removal of pathological painful disk, determines an overstressing during mastication. Although as a replacement for the disks, materials as the tendon allograft are recommended, there are no ideal inter-positioning materials that could protect the articular cartilage against the degenerative alterations induced by the discectomy.
When the illnesses are accompanied by the distruction of kinematic couples formed by condyle and disk, on one hand, and on the other, by the articular fossa and the disk and the articular fossa, the implantation of an artificial system is deemed necessary; the system has an objective to re-establish the kinematics and the dynamics of temporomandibular joint within the physiological parameters. Nevertheless, nowadays, there is a series of inconveniences regarding the long-term functioning of such an endoprosthesis.[22]

Joint replacement is a surgical procedure in which the severely affected portion of the joint is removed and replaced by a prosthetic device; the procedure is employed in special circumstances; as bony ankilosis, recurrent fibrous ankilosis, severe degenerative joint illness, aseptic necrosis of the condyle, advanced rheumatoid arthritis, condyle necrosis, advanced rheumatoid arthritis, condyle losing as a result of trauma or pathology.[23].

Different experimental studies in the field of biomechanics and physiopathology of bone consolidation ,as well as ,the investigation and improvement of the biomaterials used have led to a very rapid advance in the last 25 years in regards to techniques and systems, thanks to which a considerable decrease has occurred in the complications indexes and therapeutic failures in the management of the different craniofacial osteosynthesis techniques.[24]

Partial TMJ prostheses are used for replacing one component of TMJ-temporomandibular joint, as: articular disk, condylar replacements, and fossa replacements.
The most common condylar prosthesis used in France are: de **Caix** type 1, stelite and titanium; **Raveh** prostheses (characteristic: the adjustment of the height and the regulation of the head are made of titanium); **Mercuri** prostheses made of cobalt, molybdenum, condylar head – of titanium covered with polyethylene – a stereolithographic model; type Caix 2 prostheses have emerged; at this level, intramedular and type 3 -Caix fastening have been introduced, with the later – an auto-blocking prosthesis.[25-29]
Christensen system offers a treatment modality for severe dysfunction of

temporomandibular joint with a high rate of success. Wolford et al. ,lirature speaking ,reported that a metallic condylar head on a metallic fossa within Christensen device could amplify the accumulation of metallic debris resulted from wearing at the level of prosthesis adjacent tissues, process that induces allergic reactions in hypersensitive patients.

Total prostheses for joints are the ones that replace the condyle, and the articular fossa. Also literature said that ,previous until that moment, the surgeons have been concentrating on the implantation of a fossa or a condylar head, but not of both.[30-31]Total prostheses were presented in 1973, for the first time, by ***Michelet***. They exhibit a temporal slope made by acrylic and a mono-block medullar portion, a non-condyle and a stelite plate.

In 1978, ***Kumoona*** proposed a model for a screwed chromium-cobalt total prosthesis placed at the level of mandibular channel associated with a temporal segment of the same material.

In 1983, ***Sonnemburg*** added to condylar prosthesis a temporal segment made of polyethylene fastened at the level of zygomatic bone by means of a titanium screw.[32 -36]

Joint total prosthesis- Techmedica/TMJ Concepts -uses biomaterials recognized in orthopaedic reconstruction of hip and knee joints.

Fossa-component of this device is made from pure commercial titanium mesh (ASTM F67 & F1341) with a surface of articulation made from polyethylene with ultra-high molecular weight (UHMWPE ASTM F648). The body of the condylar component is made from titanium alloy (ASRM F136) with a surface of condylar head made form cobalt-chromium-molybdenum alloy (ASTM F1537).The fossa-component, and the condylar component are fastened by means of titanium-alloy screws (Ti-6AI-4V). Previous to joint replacement surgery, the patients is subjected to a computer tomography. By using the date collected by this method, a three-dimensional model of temporomandibular joint and of associated maxillary structures is obtained, in order to produce a truthful anatomic model. This model allows the selective repositioning of the mandible on the model in a pre-determined functional and aesthetic position.

Comparing with “universal” implant devices, a custom-made Techmedica/TMJ Concepts prosthesis provides a better adjustment and stability of the components in the host bone; the micro-movements which could determine the loosening of the components is diminished and the opportunity of component and fastening screws osseous integration is maximised.

The disposal of tissue harvesting need, in order to replace lost articular tissues of the temporomandibular joint, was accomplished by using alloplastic biomaterials. These were conceived as biologically inert substances with the desired mechanical proprieties. The silicon rubber and Proplast/Teflon (PT) constituted largely used materials in alloplastic implants starting with the middle of ’70 up to the end of ’80. Silicon rubber was used as inter-positional material, permanent or provisional, in reconstructive surgery. The implants, mostly made from carbon fibre and polytetrafluoroethylene (PTFE/Teflon or PT), were introduced by the middle of ’70, in order to reconstruct the disk following a discectomy.

In many patients, alloplastic materials have proved, in initial stage, the stopage of pain and improved functioning of the joint. The structural failure of the implants resulted in implant wear micro particles formation, which triggered a foreign body response characterised by the presence of multinucleate giant cells. ***Zardeneta et al.*** suggested that the severity of the biological answer against wear particles could be a function of particle dimension. Small wear particles trigger a more intense inflammatory process than the bigger ones.[37-40]

Another phenomenon is the entrapment of temporomandibular joint prosthesis (the development of bony tissue, osteophytes), a well-known process, diagnosed based on topographic computer, with an osteoarthritis-like symptomatology, the prosthesis being made from nickel-molybdenum-cobalt-chromium-based alloy. The entrapment developed at six months after the implantation of the prosthesis. The phenomenon was caused by the release of particles following the wear of friction couple of temporomandibular endoprosthesis. Histological, there seems to be a foreign body reaction against prosthesis material, but the reason why this reaction is so dramatic, remains unknown (2009, AAOMS).[41,42]

In order to obtain a stability as good as possible for temporomandibular implant fastening, at ISIM Timisoara, it can be developed a process of stratification of ceramic biocompatible (hydroxyapatite, alumina, zirconium) on various metallic underlayers (titanium and titanium alloys, stainless steels, etc.). By layering of biocompatible materials on metallic implants the diffusion of toxic ions in the body is prevented, the deposited layer behaves as a barrier between the metallic implant and the tissue. By controlling the parameters of plasma-jet spraying process, we can obtain rough surfaces, and by this, we can ensure a better fastening (osseous integration) of the implant. By employing bio-active deposition materials (hydroxyapatite), we obtain deposed strata that help in the rapid rebuilding of the implant-tissue link, and a longer period of functioning for the implant.

The studies regarding wear behaviour at the level of temporomandibular joint prosthesis fastening are scarce in the world; nevertheless, regarding the movements at the contact level between bone and titanium, HY Yu and SS Gao performed friction tests of two flat specimens of cortical bone harvested from fresh human mandibles, tests performed in contact with a pure titanium sphere. These tests were performed on a modified testing machine, on which a tilt of 45º was imposed between the direction of displacement and the direction of loading. The imposed maximal loadings varied from 100 to 200 N. The dynamic characteristics of friction tests have been analysed in combination with micro-examinations via optical microscopy (OM), laser confocal scanning microscopy (LCSM), and scanning electronic microscopy (SEM), together with energy dispersive X-ray spectrum (EDX). When applying the 100 N load, after 5 x 104 cycles, the authors observed only wear particles detachment and the formation of scratches; however, cracks formation was not observed; as a result, it has been concluded that the main wear mechanisms were the abrasive wear and the adhesive wear. When applying a 200 N load, the initiation of cracks was observed, with main cracks propagation on the high stress area of contact edges. Wear mechanisms of the bone consisted of a combination between abrasive, adhesive wear and the fissure of osseous tissue.

Despite the optimizations of surgical techniques and of prosthesis design, the rate of articular implant revision (the replacement of a deteriorated prosthesis with a new one) doesn’t seem to decline, the articular surface wear imposing itself as a major problem of maxillofacial surgery. In some cases, the success of an articular endoprosthesis is influenced by the wear degree of prosthetic articular surface. Wear particles generated in the process of articular prosthetic wear are accountable for osseous lysis (the destruction of osseous cells), and, by this, the thinning of osseous tissue), which constitutes a major issue in the failure of temporomandibular endoprostheses.

Recently, diamante nanostructures were applied on the surfaces of articular endoprostheses, in order to amplify the wear resistance and, as such, the durability of the endoprosthesis. Another advantage of applying these nanostructures is that of obtaining low roughness surfaces; as a result, the friction coefficient is lower, concomitant with wear mitigation, especially abrasive wear.

Other studies concentrated upon tension evaluation at the contact between the prosthesis and the bone, by employing finite element analysis. The result of these studies resided in imposing as a contact element between the mandibular or maxillary bone and the prosthesis of a titanium mesh, in a context in which titanium has a low elasticity module in comparison with other biomaterials, employed usually in endoprosthetics.[43-50]

CONCLUSION

Engineering of tissue replacements for TMD patients is emerging as a promising approach toward providing biological solutions to these as-of-yet intractable problems.

Unfortunately, no treatment consistently offers permanent recovery, and many patents require repeat therapy or follow-up surgeries . The lack of consistently successful treatment approaches necessitates development of novel solutions such as those based in tissue engineering.

REFERENCES

1. Gatchel RJ, Stowell AW, Wildenstein L, Riggs R, Ellis E. Efficacy of an early intervention for patients with acute temporomandibular disorder–related pain: a one-year outcome study. J Am Dent Assoc. 2006;137:339–347.
2. Solberg WK, Woo MW, Houston JB. Prevalence of mandibular dysfunction in young adults. J Am Dent Assoc. 1979;98:25–34.
3. Van Loon JP, De Bont L, Stegenga B, Spijkervet F, Verkerke G. Groningen temporomandibular joint prosthesis. Development and first clinical application. Int J Oral Maxillofac Surg. 2002
4. Bracco P, Deregibus A, Piscetta R. Effects of different jaw relations on postural stability in human subjects. Neurosci Lett. 2004;356:228–30.
5. O.Driemel,S.Braun ,U.D.A.Müller-Richter,M.Behr,T.E.Reichert,M.Kunkel,R.Reich, Historical development of alloplastic temporomandibular joint replacement after 1945 and state of the art International Journal of Oral and Maxillofacial SurgeryVolume 38, Issue 9, September 2009, Pages 909-920
6. Burlui ,V.Morarasu C.Gnatologie Editura Apollonia Iasi 2000.
7. Athanasiou KA, Almarza AJ, Detamore MS, Kalpakci KN. Tissue engineering of temporomandibular joint cartilage. Synthesis Lectures on Tissue Engineering. 2009;1:1–122.
8. Chisnoiu AM, Picos AM, Popa S, Chisnoiu PD, Lascu L, Picos A, Chisnoiu R. Factors involved in the etiology of temporomandibular disorders-a literature review. Clujul Medical. 2015;88:473.
9. Segami N, Suzuki T, Sato J, Miyamaru M, Nishimura M, Yoshimura H (2003). Does joint effusion on T2 magnetic resonance images reflect synovitis? Part 3. Comparison of histologic findings of arthroscopically obtained synovium in internal derangements of the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 95:761-766.
10. Suvinen TI, Reade PC. Temporomandibular Disorders: A Critical Review of the Nature of Pain and Its Assessment. J Orofac Pain. 1995;9

11. Klasser GD, Greene CS. Oral appliances in the management of temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107:212–223. [PubMed] [Google Scholar
12. Ingawalé S, Goswami T. Temporomandibular joint: disorders, treatments, and biomechanics. Ann Biomed Eng. 2009;37:976–996
13. Machado E, Bonotto D, Cunali PA. Intra-articular injections with corticosteroids and sodium hyaluronate for treating temporomandibular joint disorders: a systematic review. Dental Press J Orthod. 2013;18:128–133
14. Carvajal WA, Laskin DM. Long-term evaluation of arthrocentesis for the treatment of internal derangements of the temporomandibular joint. J Oral Maxillofac Surg. 2000;58:852–855.
15. Hibi H, Yamada Y, Ueda M, Endo Y., Alveolar cleft osteoplasty using tissue-engineered osteogenic material, Int J Oral Maxillofac Surg. 2006 Jun;35(6):551-5. Epub 2006 Apr 11.
16. Klasser GD, Greene CS. Oral appliances in the management of temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107:212–223.
17. Al-Ani MZ, Davies SJ, Gray RJM, Sloan P, Glenny AM. Stabilisation splint therapy for temporomandibular pain dysfunction syndrome. Cochrane Database Syst Rev. 2004:CD002778.
18. Fouladpour N, Jesudoss R, Bolden N, Shaman Z, Auckley D. Perioperative complications in obstructive sleep apnea patients undergoing surgery: a review of the legal literature. Anesthesia and Analgesia 2016; 122: 145–51.
19. Isberg A (2001). Temporomandibular joint dysfunction: A practitioner's guide. ISIS Medical media. ISBN 1-901865-44-4.
20. Isberg A, Legrell PE (2000). Facial asymmetry in adults following temporomandibular joint disc displacement with onset during growth. World J Orthod 1:164-172.
21. Isberg AM, McNamara JA Jr, Carlson DS, Isacsson G (1990). Coronoid process elongation in rhesus monkeys (Macaca Mulatta) after experimentally induced mandibular hypomobility. A cephalometric and histologic study. Oral Surg Oral Med Oral Pathol 70:704-710.
22. Isacsson G, Linde C, Isberg A (1989). Subjective symptoms in patients with temporomandibular joint disk displacement versus patients with myogenic craniomandibular disorders. J Prosthet Dent 61:70-77.
23. Bowerman J Reconstruction of the temporomandibular joint for acquired deformity and congenital malformation. Br J Oral Maxillofac Surg.1987;25:149-160.
24. Mercuri LG. The use of alloplastic prostheses for temporomandibular joint reconstruction. J Oral Maxillofac Surg. 2000;58:70–75.
25. Ravosa MJ, Kunwar R, Stock SR, Stack MS. Pushing the limit: masticatory stress and adaptive plasticity in mammalian craniomandibular joints. J Exp Biol. 2007;210:628–641
26. Vuillemin T.,,Raveh J.,Sutter F., Mandibular reconstruction with the THORP condylar prosthesis after hemimandibulectomy, journal of Cranio-Maxillofacial SurgeryVolume 17, Issue 2, February 1989, Pages 78-87
27. Caix P., l'articulation temporo-mandibulaire et son vrai-faux ménisque, Thèse de Doctorat, Université de Picardie, 1991
28. Mercuri L., The use of alloplastic prostheses for temporomandibular joint reconstruction. J Oral and Maxillofac Surg 58: 70-75, 2000
29. Mercuri L., Wolford L., Sanders B., White D., Hurder A., Henderson W., Custom CAD/CAM total temporomandibular joint reconstruction system. Preliminary multicenter report, J Oral MaxillofacSurg 53 : 106-115, 1995
30. Christensen R., The temporomandibular joint prosthesis eleven years later. Oral Implantol 2:125, 1971

31. Wolford LM. Temporomandibular joint devices: treatment factors and outcomes. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997;83:143–149.
32. Michelet F.X.Benoit J.P.Pinsolles J.Dessus B.Les prosthèses totales des articulations temporo-mandibulaires.Rev de Stomatol. 1973; 74: 647-649
33. Sonnenburg I.,Sonnenburg M.Total condylar prosthesis for alloplastic jaw articulation replacement.J Maxillofac Surg. 1985; 13: 131-135
34. Quinn P.Surgical approaches to the temporomandibular joint.in: Quinn P. Color Atlas of Temporomandibular Joint Surgery. Mosby, St Louis1998: 30-54
35. Quinn P.,Surgical approaches to the temporomandibular joinin: Quinn P. Color Atlas of Temporomandibular Joint Surgery. Mosby, St Louis1998: 30-54
36. Kameros J.Himmelfarb R.Treatment of temporomandibular joint ankylosis with methyl methacrylate interpositioned arthroplasty: report of four cases.J Oral Surg. 1975; 33: 282-287
37. Milam SB, Zardeneta G, Schmitz JP. Oxidative stress and degenerative temporomandibular joint disease: A proposed hypothesis. J Oral Maxillfac Surg 1998;56(2): 214-33.
38. Buckinham RB, Braun T, Harinstein DA, et al. Temporomandibular joint dysfunction syndrome: A close association with systemic joint laxity (the hypermobile joint syndrome). Oral Surg Oral Med Oral Pathol 1991;72(5): 514-9.
39. Magnusson T, Carlsson GE, Egermark I. Changes in clinical signs of craniomandibular disorders from the age of 15 to 25 years. J Orofac Pain 1994;8(2):207-15
40. Sato S, Ohta M, Ohki H, Kawamura H, Motegi K: Effect of lavage with injection of hyaluronic acid for patients with nonreducing disk displacement of the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 84: 241e244, 1997
41. American Academy of Pediatric Dentistry. Guidelines for temporomandibular disorders in children and adolescents. Chicago, Ill.: American Academy of Pediatric Dentistry; 1990.
42. American Academy of Pediatric Dentistry. Acquired temporomandibular disorders in infants, children, and adolescents. Pediatr Dent 2015;37(special issue):272-8.
43. Gao S, Cai Z, Quan H et al. Comparison between radial fretting and dual-motion fretting features of cortical bone. Tribol Int 2010; 43(1/2): 44
44. Yu H, Cai Z, Zhu M et al. [Research on fretting behaviors of axial cortical bone of femur.] Chin J Mech Eng 2005; 41 (8): 149–152.
45. Yu HY, Quan HX, Cai ZB et al. Radial fretting behavior of cortical bone against titanium. Tribol Lett 2008; 31(2): 69–76.
46. Yu HY, Cai ZB, Zhou ZR et al. Fretting behavior of cortical bone against titanium and its alloy. Wear 2005; 259(7/8/9/10/11/12): 910–918.
47. Posnick JCJacobs JSMagee WP Prosthetic replacement of the condylar head for temporomandibular joint disease. Plast Reconstr Surg.1987;80:536-544
48. Bahr W, Stricker A, Gutwald R, Wellens E. Biodegradable osteosynthesis material for stabilization of maxillary fractures: experimental investigation in sheep. J Craniomaxillofac Surg 1999;27:51-7.
49. Spencer KRSizeland ATaylor GIWiesenfeld D The use of titanium mandibular reconstruction plates in patients with oral cancer. Int J Oral Maxillofac Surg.1999;28:288-290.Google
50. Lindqvist CSoderholm ALHallikainen DSjovall L Erosion and heterotopic bone formation after alloplastic temporomandibular joint reconstruction. J Oral Maxillofac Surg.1992;50:942-949