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PREFACE

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We thank all of the authors with whom we collaborated to publish their books across disciplines.

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Chapter 1

RECOMMENDATIONS FOR THE SELECTION AND USE OF MASKS FOR DENTAL STAFF DURING THE NOVEL CORONAVIRUS PANDEMIC

Muhammet Kerim AYAR[1]

INTRODUCTION

Since the 21st century, there have been many highly pathogenic viruses spread through the respiratory tract and/or contact routes around the world, such as severe acute respiratory syndrome (SARS), influenza A H1N1 virus (H1N1), Middle East respiratory syndrome (MERS). Since the late of 2019, the new coronavirus (2019-nCoV) that is widely circulating around the world pose a serious threat to people's health. During the pandemic, higher incidence of infection is observed among medical stuff compared to the other part of the society. Thus, it has become particularly important for medical stuff to treat patients more safely and effectively without being infected.[1] The nature of the dental profession determines that it faces a huge risk of infection during the diagnosis and treatment process, especially the respiratory tract transmission caused by droplets and aerosols, which are the most important risk factors in the oral diagnosis and treatment process.[2] In this review, the types, evaluation criteria and the standards requirements of medical masks in different geographies of the world such as the United States of America (USA), the European Union (EU) and the People's Republic of China (China) are emphasized in order to effectively prevent the spread of the virus, avoid nosocomial infections, and occupational exposure of medical staff during novel coronavirus pandemic.

The Transmission Route of the New Coronavirus in the Oral Diagnosis and Treatment Process and Risk

During the oral diagnosis and treatment, dental staff need to perform close operations within the patient's mouth, and face high risk factors such as the complexity, invasiveness, and the complexity of the spread of infection during the oral diagnosis and treatment.[3] The understanding the transmission routes and risks of infectious viruses in the oral diagnosis and treatment is of great significance to preventing infections. In the dental setting, the transmission route of the new coronavirus mainly has the following characteristics.

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PROTECTION STANDARDS FOR MEDICAL MASKS UNDER THE NEW CORONAVIRUS PANDEMIC

It is pointed out that during the new coronavirus pandemic, the use of protective mask should be strictly divided according to the classification. Different medical positions and diagnosis and treatment operations should use different types of medical masks (Table 5), including medical protective masks (GB19083-2010) and N95 particles protective masks (American NIOSH and FDA standards) are assigned to medical staff who have aerosol generating procedures. When materials are in short supply and there are no medical protective masks and N95 masks that meet the US NI0SH and FDA standards, particle protective masks with N95/ FFP2 and above standards and KN95 protective masks can be used with medical surgical masks as appropriate to perform splash treatment operations.

CONCLUSION

This article introduces the types, evaluation criteria and standard requirements of medical masks at worldwide. For the selection of medical masks, the main consideration is the filtering effect of the masks against non-oil particles, the anti-splashing ability and the medical environment in which they are used. During the new coronavirus pandemic, the choice of masks has become very important. An analysis of the parameter standards of medical masks and anti-particle protective masks at worldwide revealed that the US level 1 and EU type I and type II medical masks can be used as disposable medical masks. USA level 2 and 3 and EU type II R medical masks can be used as medical surgical mask. According to the anti-oil particle filtering effect, N100 = KN100 > FFP3 = N99 = KN99 > N95 = KN95 > FFP2 > KN9O > FFP1, but the anti-particle protective mask is not equivalent to the medical protective mask.

REFERENCES

1. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. *JAMA*. 2020; 323 (11), 1061-1069.
2. Zemouri C, de Soet H, Crielaard W, Laheij A. A scoping review on bio-aerosols in healthcare and the dental environment. *PloS one*. 2017; 12 (5, :e0178007.
3. Nejatidanesh F, Khosravi Z, Goroohi H, Badrian H, Savabi O. Risk of contamination of different areas of dentist's face during dental practices. *International journal of preventive medicine*. 2013; 4 (5), 611.
4. Harrel SK, Molinari J. Aerosols and splatter in dentistry: a brief review of the literature and infection control implications. *The Journal of the American Dental Association*. 2004; 135 (4), 429-437.
5. SGS. CHINA RELEASES AN UPDATED MANDATORY STANDARD GB 2626-2019 RESPIRATORY PROTECTION - NON-POWERED AIR-PURIFYING PARTICLE RESPIRATOR. 2020. Accessed 4-6, 2021.

6. Bałazy A, Toivola M, Adhikari A, Sivasubramani SK, Reponen T, Grinshpun SA. Do N95 respirators provide 95% protection level against airborne viruses, and how adequate are surgical masks? *American journal of infection control.* 2006; 34 (2), 51-57.

Chapter 2

BONE ANCHORED RAPID MAXILLARY EXPANSION

Berkan KUCUKKURT[1]
Emre KAYALAR[2]

INTRODUCTION

Irregularities that can occur in the teeth, jaw and facial system for various reasons can cause malocclusions between the jaws and these malocclusions can negatively affect the aesthetics of the face and smile.

In today's aesthetic understanding, the presence of buccal corridors and dark triangles that can be seen in the posterior regions are perceived as aesthetic losses. Such aesthetic losses may be directly or indirectly related to the skeletal base of the maxilla, the inclination of the teeth in the buccal area and the alveolar bone surrounding these teeth [1]. Therefore, it is recommended to correct the dimensional anomalies of the maxilla, which has occurred due to various reasons, with orthodontic treatment, and to ideally treat the transversal position of the teeth in particular [2].

Malocclusions can occur in transversal, vertical and sagittal directions. The most common malocclusions in the transversal direction are maxillary deficiency, and occlusion disorders that can be seen with unilateral or bilateral crossbites in the anterior and/or posterior teeth region [3].

Posterior crossbite [4], which is thought to play a role in the etiology of genetic, environmental and multifactorial factors, can be related to a single tooth [5,6] or a group of teeth [5], skeletally due to maxillary deficiency or a large transversal mandible it may also be due to.

The most commonly used treatment method in the treatment of maxillary transversal deficiency and posterior crossbite is expansion of the maxilla. If there is only a deficiency of the dental arch without a transverse deficiency at the base of the maxillary apical bone, only the dental arch needs to be expanded [4,5,8]. According to the opening speed of the median palatal suture; It can be done slow,

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may occur. To overcome these, the surgical assisted rapid maxillary expansion method for adults has been developed, and also first generation bone-borne distractors have been developed to minimize dental side effects.

It has been argued that since these devices provide the anchorage requirement from the bone, they reduce these side effects and allow a pure orthopedic expansion. Less invasive techniques have been developed with the introduction of mini-screws into orthodontic practice, as distactors require surgical procedures during their application.

It has been shown that successful results are obtained in treatments with mini-screw assisted expansion appliances supported by the palatal bone. Even in recent years, studies have been published reporting mini-screw-assisted and non-surgical expansion in adult patients. As seen in the current literature, many different bone anchored maxillary expansion appliances are being developed. More clinical studies are needed on the long-term effects of these appliances.

REFERENCES

1. Solow B. The dentoalveolar compensatory mechanism: background and clinical implications. Br J Orthod. 1980;7:145-61.
2. Zachrisson BU. Estehetic factors involved in anterior tooth display and the smile, vertical dimention. J Clin Orthod. 1998;32:432-445.
3. Ferrario VF, Garattini G, Colombo A, Quantitative effects of a nickeltitanium palatal expander on skeletal and dental structures in the primary and mixed dentition: a preliminary study. Eur J Orthod. 2003;25:401-10.
4. Bishara SE, Staley RN. Maxillary expansion: clinical implications. Am J Orthod Dentofacial Orthop 1987;91:3-14.
5. Kutin G, Hawes RR. Posterior cross-bites in the deciduous and mixed dentitions. American Journal of Orthodontics, 1969,56:491-504.
6. Nerder PH, Bakke M, Solow B. The functional shift of the mandible in unilateral posterior crossbite and the adaptation of the temporomandibular joints: a pilot study. European Journal of Orthodontics, 1999,21:155-66.
7. Haas AJ. Rapid expansion of the maksillary dental arch and nasal cavity by opening the mid-palatal suture. Angle Orthod. 1961; 31: 73-90.
8. Ülgen M. Anomaliler, Sefalometri, Etyoloji, Büyüme ve Gelişim, Tanı, Ortodonti, İstanbul, Yeditepe Üniversitesi Yayınları, 2000.
9. Di Paolo RJ. Thoughts on palatal expansion. J Clin Orthod. 1970;4: 493-497.
10. Graber TM, Vanarsdall JRL, Vig KWL. Orthodontics: Currents Principles and Tecniques. Fourth Edition, St. Luois, Missouri, Elsevier, Mosby, 2005.
11. Zimring JF, Isaacson RJ. Forces Produced by Rapid Maksillary Expansion. 3. Forces Present during Retention. Angle Orthod. 1965;35: 178-186.
12. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. Am J Orthod 58:41-66,1970.
13. Haas AJ. Palatal expansion: Just the beginning of dentofacial orthopedics. Am J Orthod 1970;57:219-255.
14. Bell WH, Epker BN. Surgical-orthodontic expansion of the maxilla. Am J Orthod 1976;70:517-528.
15. Starch-Jensen T, Blæhr TL. Transverse Expansion and Stability after Segmental Le Fort I

Osteotomy versus Surgically Assisted Rapid Maxillary Expansion: a Systematic Review. J Oral Maxillofac Surg. 2016;7(4):e1.
16. Brown GVI. The surgery of oral and facial diseases and malformations: their diagnosis and treatment including plastic surgical reconstruction. London: Lea and Febiger; 1938
17. Pogrel MA, Kaban LB, Vargervik K, Surgically assisted rapid maxillary expansion in adults. Int J Adult Orthodon Orthognath Surg. 1992;7:37-41.
18. Gürler G, Akar NK, Delilbaşı Ç, Skeletal changes following surgically assisted rapid maxillary expansion (SARME). Eur oral Res. 2018;52(2):94-98.
19. Kayalar, E., Schauseil, M., Kuvat, S., V. et al. Comparison of tooth-borne and hybrid devices in surgically assisted rapid maxillary expansion: a randomized clinical cone-beam computed tomography study. Journal of Cranio-Maxillofacial Surgery, 2016;44(3), 285-293.
20. Chaconas SJ, Caputo AA. Observation of orthopedic force distribution produced by maxillary orthodontic appliances. Am J Orthod. 1982 Dec;82(6):492-501. Doi: 10.1016/0002-9416(82)90318-9.
21. Ferrario VF, Sforza C, Serrao G, Growth and aging of facial soft tissues: A computerized three-dimensional mesh diagram analysis. Clin Anat. 2003 Sep;16(5):420-33. Doi: 10.1002/ca.10154.
22. Baccetti T, Franchi L, Cameron CG, Jr Treatment timing for rapid maxillary expansion. Angle Orthod
23. Angelieri F, Cevidanes LH, Franchi L, Midpalatal suture maturation classification method for individual assessment before rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2013;144(5):759–769.
24. Lima AL, Silva RMA, Filho, Bolognese AM. Longterm clinical outcome of rapid maxillary expansion as the only treatment performed in Class I malocclusion. Angle Orthod. 2005;75(3):416–420.
25. Persson M, Thilander B. Palatal suture closure in man from 15 to 35 years of age. Am J Orthod. 1977;72(1):42–52.
26. Korbmacher H, Schilling A, Püschel K, Age-dependent threedimensional micro-computed tomography analysis of the human midpalatal suture. J Orofac Orthop. 2007;68(5):364–376.
27. Handelman CS, Wang L, BeGole EA, Nonsurgical rapid maxillary expansion in adults Report on 47 cases using the Haas expander. Angle Orthod. 2000;70(2):129–144.
28. Byloff FK, Mossaz CF. Skeletal and dental changes following surgically assisted rapid palatal expansion. Eur J Orthod. 2004;26(4):403-409.
29. Capelozza L, Filho, Cardoso J, Neto, Silva OG, Non-surgically assisted rapid maxillary expansion in adults. Int J Adult Orthod Orthognath Surg. 1996;11(1):57–66.
30. Siqueira DF, Cardoso MA, Capelozza L, Periodontal and dental effects of surgically assisted rapid maxillary expansion, assessed by using digital study models. Dental Press J Orthod. 2015;20(3):58-63.
31. Lee KJ, Park YC, Park JY, Miniscrew-assisted nonsurgical palatal expansion before orthognathic surgery for a patient with severe mandibular prognathism. Am J Orthod Dentofacial Orthop. 2010;137(6):830–839.
32. Carlson C, Sung J, McComb RW, Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult. Am J Orthod Dentofacial Orthop. 2016;149(5):716-728.
33. Choi SH, Shi KK, Cha JY, Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. Angle Orthod. 2016;86(5):713–720.
34. Timms DJ. Emerson C. Angell Founding father of rapid maxillary expansion. Dent Hist 1997:3-12.
35. Northway WM, Meade JB, Jr. Surgically assisted rapid maxillary expansion: a comparison of technique, response, and stability. Angle Orthod 1997;67:309-20.
36. Mossaz CF, Byloff FK, Richter M. Unilateral and bilateral corticotomies for correction of maxillary transverse discrepancies. Eur J Orthod 1992;14:110-6.
37. Moss JP. Rapid expansion of the maxillary arch. Part I. JPO J Pract Orthod 1960;2:215-21.

38. Isaacson RJ, Ingram AH. Forces Produced by Rapid Maxillary Expansion. I: Forces Present during Retention. Angle Orthod 1964;34:256-60.
39. Mommaerts MY. Transpalatal distraction as a method of maxillary expansion. Br J Oral Maxillofacial Surg. 1999;37: 268-272.
40. Kraut RA. Surgically assisted rapid maxillary expansion byopening the midpalatal suture. J Oral Maxillofac Surg. 1984;42:651–655.
41. Anderson L. KKE, Porgel M.E. , editor. Oral and Maxillofacial Surgery 2010.
42. Gerlach KL, Zahl C. Transversal palatal expansion using palatal distractor. J Orofac Orthop 2003;64:443-9.
43. Koudstaal MJ, van der Wal KG, Wolvius EB, Schulten AJ. The Rotterdam Palatal Distractor: introduction of the new bone-borne device and report of the pilot study. Int J Oral Maxillofac Surg 2006;35:31-5.
44. Cortese A, Savastano M, Savastano G, Maxillary constriction treated by a new palatal distractor device: surgical and occlusal evaluations of 10 patients. J Craniofac Surg 2010;21:339-43
45. Lagravere MO, Carey J, Heo G, Transverse, vertical, and anteroposterior changes from bone-anchored maxillary expansion vs traditional rapid maxillary expansion: a randomized clinical trial. Am J Orthod Dentofacial Orthop 2010;137:304 e1-12; discussion -5.
46. Harzer W, Schneider M, Gedrange T. Rapid maxillary expansion with palatal anchorage of the hyrax expansion screw--pilot study with case presentation. J Orofac Orthop 2004;65:419-24.
47. Pinto PX, Mommaerts MY, Wreakes G, Immediate postexpansion changes following the use of the transpalatal distractor. J Oral Maxillofac Surg 2001;59:994-1000; discussion 1.
48. Zandi M, Miresmaeili A, Heidari A. Short-term skeletal and dental changes following bone-borne versus tooth-borne surgically assisted rapid maxillary expansion: A randomized clinical trial study. J Craniomaxillofac Surg 2014.
49. Neyt NM, Mommaerts MY, Abeloos JV, Problems, obstacles and complications with transpalatal distraction in non-congenital deformities. J Craniomaxillofac Surg 2002;30:139-43.
50. Koudstaal MJ, Smeets JB, Kleinrensink GJ, Relapse and stability of surgically assisted rapid maxillary expansion: an anatomic biomechanical study. J Oral Maxillofac Surg 2009;67:10-4.
51. Wilmes B, Nienkemper M, Drescher D. Application and effectiveness of a miniimplant- and tooth-borne rapid palatal expansion device: the hybrid hyrax. World J Orthod 2010;11:323-30.
52. Lee, Kee-Joon, et al. "Miniscrew-assisted nonsurgical palatal expansion before orthognathic surgery for a patient with severe mandibular prognathism. American Journal of Orthodontics and Dentofacial Orthopedics 137.6 (2010): 830-839
53. Proffit, W.R.; Phillips, C.; and Dann, C.T.: Who seeks surgical orthodontic treatment Int. J. Adult Orthod. Orthog. Surg. 1990;5:153-160.
54. Bud, E. S., et al. "Observational Study Regarding Possible Side Effects of Miniscrew-Assisted Rapid Palatal Expander (MARPE) with or without the Use of Corticopuncture Therapy. Biology 2021,10,187.
55. Suzuki, H.; Moon, W.; Previdente, L.H. Miniscrew-assisted rapid palatal expander (MARPE): The quest for pure orthopedic movement, Dent. Press J. Orthod. 2016;21:17-23.
56. Holberg, C.; Winterhalder, P.; Rudzki-Janson,I Finite element analysis of mono- and bicortical mini-implant stability, Eur. J. Orthod. 2014;36:550-556.
57. Brettin, B.; Grosland, N.; Qian, F., Bicortical vs monocortical orthodontic skeletal anchorage, Am. J. Orthod. 2008;134:625-635.
58. Lee, R.; Moon, W.; and Hong, C.: Effects of monocortical and bicortical mini-implant anchorage on boneborne palatal expansion using finite element analysis, Am. J. Orthod. 2017;151:887-897.
59. Lin, L.; Ahn, H.; Kim, S. Tooth-borne vs boneborne rapid maxillary expanders in late adolescence, Angle Orthod. 2014;85:253-262.
60. Lupini D et al. "A Tissue and Boneborne Rapid Palatal Expander." J. Clin. Orthod 2020;54:210-220.
61. Bazargani, F.; Feldmann, I.; and Bondemark, L.: Three-dimensional analysis of effects of rapid

maxillary expansion on facial sutures and bones, Angle Orthod. 2013;83:1074-1082.
62. Braun, S.; Bottrel, J.; Lee, K.; The biomechanics of rapid maxillary sutural expansion, Am. J. Orthod. 2000;118:257-261.
63. Winsauer, Heinz, et al. "A bone-borne appliance for rapid maxillary expansion." Journal of clinical orthodontics: JCO 47.6 2013;375-388.
64. Wilmes B, Nienkemper M, Drescher D. Application and effectiveness of a miniimplant-and tooth-borne rapid palatal expansion device: the hybrid hyrax. World J Orthod 2010;11:323-30.

Chapter 3

OBSTRUCTIVE SLEEP APNEA MANAGEMENT IN PROSTHETIC DENTISTRY

Eyyup ALTINTAS[1]

INTRODUCTION

In contemporary times, one of the first physicians to talk about sleep apnea Sir William Osler. "Principles and Practice of Medicine", in his book, Pickwickian Disease has defined.[1] In 1976, by describing this disease, Guilleminaultt et al.[2] changed the name of the disease known as the Pickwickian syndrome to Obstructive sleep apnea(OSA). In 1981 Sullivan et al.[3] found continuous positive airway pressure (CPAP) therapy, which is still considered the gold standard in the treatment of the disease. In 1982, a neuropsychiatrist Dr. Cartwright[4] treated 22 patients using splints and published its results. Subsequently, dentists have been included in the treatment of OSA. The last classification of sleep disorders was published by the name of "International Classification of Sleep Disorders-3" (ICSD-3) in 2014.[5] Sleep disorders defined in ICSD-3 classification analyzed under the 7 main categories.

ICSD-3 classification

1) Insomnias
   a) Chronic insomnia disorder
   b) Short-term insomnia disorder
   c) Other insomnia disorders
2) Breathing disorders during sleep
   a) OSA
   b) Central sleep apnea
   c) Hypoventilation during sleep
   d) Hypoxemic syndromes during sleep
3) Central-induced hypersomnias
   a) Narcolepsy Type 1

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be tolerated by the patient. Long-term follow-up of the patient is important for successful treatment in OSA patients.

REFERENCES

1. Songu, M. (2010). Horlama ve Obstrüktif Uyku ApnesindeTarihçe ve Tanımlar. Cemal Cingi (Ed.). Horlama ve obstrüktif uyku apnesi(1-19). Istanbul. Deomed Medikal Yayıncılık
2. Guilleminault C, Tilkian A, Dement WC. The sleep apnea syndromes. Annu Rev Med. 1976;27:465-484.
3. Sullivan CE, Issa FG, Berthon-Jones M, Eves L. Reversal of obstructive sleep apnoea by continuous positive airway pressure applied through the nares. Lancet. 1981;1(8225):862-865.
4. Cartwright RD, Samelson CF. The effects of a nonsurgical treatment for obstructive sleep apnea. The tongue-retaining device. Jama. 1982;248(6):705-709.
5. Sateia MJ. International classification of sleep disorders-third edition: highlights and modifications. Chest. 2014;146(5):1387-1394.
6. AlRumaih HS, Baba NZ, AlShehri A, AlHelal A, Al-Humaidan A. Obstructive Sleep Apnea Management: An Overview of the Literature. J Prosthodont. 2018;27(3):260-265.
7. Wang W, Di C, Mona S, Wang L, Hans M. Tongue Function: An Underrecognized Component in the Treatment of Obstructive Sleep Apnea with Mandibular Repositioning Appliance. Can Respir J. 2018;2018:2157974.
8. Ngiam J, Balasubramaniam R, Darendeliler MA, Cheng AT, Waters K, Sullivan CE. Clinical guidelines for oral appliance therapy in the treatment of snoring and obstructive sleep apnoea. Aust Dent J. 2013;58(4):408-419.
9. Faber J, Faber C, Faber AP. Obstructive sleep apnea in adults. Dental Press J Orthod. 2019;24(3):99-109.
10. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. Sleep. 1999;22(5):667-689.
11. Ernst G, Bosio M, Salvado A, Dibur E, Nigro C, Borsini E. Difference between apnea-hypopnea index (AHI) and oxygen desaturation index (ODI): proportional increase associated with degree of obesity. Sleep Breath. 2016;20(4):1175-1183.
12. Derneği TT. obstrüktif uyku apne sendromu tanı ve tedavi uzlaşı raporu. Türk Torak Dergisi. 2012;13:66.
13. Epstein LJ, Kristo D, Strollo PJ, Jr., et al. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. J Clin Sleep Med. 2009;5(3):263-276.
14. Yoshida K. Effects of a mandibular advancement device for the treatment of sleep apnea syndrome and snoring on respiratory function and sleep quality. Cranio. 2000;18(2):98-105.
15. Deegan PC, McNicholas WT. Pathophysiology of obstructive sleep apnoea. Eur Respir J. 1995;8(7):1161-1178.
16. Piskin B, Sentut F, Sevketbeyoglu H, et al. Efficacy of a modified mandibular advancement device for a totally edentulous patient with severe obstructive sleep apnea. Sleep Breath. 2010;14(1):81-85.
17. Johal A, Battagel JM. Current principles in the management of obstructive sleep apnoea with mandibular advancement appliances. Br Dent J. 2001;190(10):532-536.
18. Endo S, Mataki S, Kurosaki N. Cephalometric evaluation of craniofacial and upper airway structures in Japanese patients with obstructive sleep apnea. J Med Dent Sci. 2003;50(1):109-120.
19. Segal Y, Malhotra A, Pillar G. Upper airway length may be associated with the severity of obstructive sleep apnea syndrome. Sleep Breath. 2008;12(4):311-316.
20. Li Y, Lin N, Ye J, Chang Q, Han D, Sperry A. Upper airway fat tissue distribution in subjects with obstructive sleep apnea and its effect on retropalatal mechanical loads. Respir Care.

2012;57(7):1098-1105.
21. Nayar S, Knox J. Management of obstructive sleep apnea in an edentulous patient with a mandibular advancement splint: a clinical report. J Prosthet Dent. 2005;94(2):108-111.
22. Rogers RR. Oral Appliance Therapy for the Management of Sleep Disordered Breathing: An Overview. Sleep Breath. 2000;4(2):79-84.
23. Pae EK, Lowe AA, Fleetham JA. A role of pharyngeal length in obstructive sleep apnea patients. Am J Orthod Dentofacial Orthop. 1997;111(1):12-17.
24. Piskin B, Hakan A, Sentut F. Obstrüktif uyku apnesinde oral aparey kullanımı. Cumhuriyet Dental Journal. 2012;15(3):264-278.
25. Kushida CA. (2007). Obstructive sleep apnea: Pathophysiology, comorbitities and consequences. Vol 3. New York: İnforma Health Care
26. Armijo-Olivo S, Jara X, Castillo N, et al. A comparison of the head and cervical posture between the self-balanced position and the Frankfurt method. J Oral Rehabil. 2006;33(3):194-201.
27. Yamaoka M, Furusawa K, Uematsu T, Okafuji N, Kayamoto D, Kurihara S. Relationship of the hyoid bone and posterior surface of the tongue in prognathism and micrognathia. J Oral Rehabil. 2003;30(9):914-920.
28. Cistulli PA, Sutherland K. Phenotyping obstructive sleep apnoea-Bringing precision to oral appliance therapy. J Oral Rehabil. 2019;46(12):1185-1191.
29. Peppard PE, Young T, Palta M, Dempsey J, Skatrud J. Longitudinal study of moderate weight change and sleep-disordered breathing. Jama. 2000;284(23):3015-3021.
30. Krishnan V, Dixon-Williams S, Thornton JD. Where there is smoke…there is sleep apnea: exploring the relationship between smoking and sleep apnea. Chest. 2014;146(6):1673-1680.
31. Akkaya A, Öztürk, Ö. Uyku Apne Sendromu Tanı Yöntemleri. Turkiye Klinikleri 2008;1:50-57.
32. Kushida C. 2013. Encyclopedia of sleep. Vol 4. Oxford: Academic Press.
33. Stuck BA, Maurer JT. Airway evaluation in obstructive sleep apnea. Sleep Med Rev. 2008;12(6):411-436.
34. Kapa S, Gami AS, Somer VK. (2011). Obstructive sleep apnea and hypertension: Interactions and clinical implications. Pack A.I. (Ed.) Sleep Apnea: Pathogenesis, Diagnosis and Treatment(p. 236–250). Philadelphia, Pennsylvania: 2nd Et
35. Suen C, Ryan CM, Mubashir T, et al. Sleep Study and Oximetry Parameters for Predicting Postoperative Complications in Patients With OSA. Chest. 2019;155(4):855-867.
36. Teculescu D, Benamghar L, Hannhart B, Michaely JP. Habitual loud snoring. A study of prevalence and associations in 850 middle-aged French males. Respiration. 2006;73(1):68-72.
37. Van de Louw A, Cracco C, Cerf C, et al. Accuracy of pulse oximetry in the intensive care unit. Intensive Care Med. 2001;27(10):1606-1613.
38. Obstructive sleep apnoea: Toolkit for commissioning and planning local NHS services in the UK (2019). (Date on 20.08.2021,reachedathttps://www.blf.org.uk/sites/default/files/OSA_Toolkit_2015_BLF_0.pdf)
39. Veasey SC, Guilleminault C, Strohl KP, Sanders MH, Ballard RD, Magalang UJ. Medical therapy for obstructive sleep apnea: a review by the Medical Therapy for Obstructive Sleep Apnea Task Force of the Standards of Practice Committee of the American Academy of Sleep Medicine. Sleep. 2006;29(8):1036-1044.
40. Löth S, Petruson B. Improved nasal breathing reduces snoring and morning tiredness. A 6-month follow-up study. Arch Otolaryngol Head Neck Surg. 1996;122(12):1337-1340.
41. Shapiro GK, Shapiro CM. Factors that influence CPAP adherence: an overview. Sleep Breath. 2010;14(4):323-335.
42. Isetta V, Navajas D, Montserrat JM, Farré R. Comparative assessment of several automatic CPAP devices' responses: a bench test study. ERJ Open Res. 2015;1(1).
43. İşeri H., Khalil S.Obstrüktif Uyku Apne Sendromunda Diş Hekimliği Uygulamaları: Mandibuler İlerletme Aygıtı. Turkiye Klinikleri Pulmonary Medicine-Special Topics 2008;1:102-109.
44. Sutherland K, Vanderveken OM, Tsuda H, et al. Oral appliance treatment for obstructive sleep apnea: an update. J Clin Sleep Med. 2014;10(2):215-227.

45. Kushida CA, Morgenthaler TI, Littner MR, et al. Practice parameters for the treatment of snoring and Obstructive Sleep Apnea with oral appliances: an update for 2005. Sleep. 2006;29(2):240-243.
46. Ng JH, Yow M. Oral Appliances in the Management of Obstructive Sleep Apnea. Sleep Med Clin. 2019;14(1):109-118.
47. Brunzini A, Gracco A, Mazzoli A, Mandolini M, Manieri S, Germani M. Preliminary simulation model toward the study of the effects caused by different mandibular advancement devices in OSAS treatment. Comput Methods Biomech Biomed Engin. 2018;21(13):693-702.
48. Mohsenin N, Mostofi MT, Mohsenin V. The role of oral appliances in treating obstructive sleep apnea. J Am Dent Assoc. 2003;134(4):442-449.
49. Battagel JM, Johal A, Kotecha BT. Sleep nasendoscopy as a predictor of treatment success in snorers using mandibular advancement splints. J Laryngol Otol. 2005;119(2):106-112.
50. Cistulli PA, Gotsopoulos H, Marklund M, Lowe AA. Treatment of snoring and obstructive sleep apnea with mandibular repositioning appliances. Sleep Med Rev. 2004;8(6):443-457.
51. Sutherland K, Chan AS, Cistulli PA. Three-dimensional assessment of anatomical balance and oral appliance treatment outcome in obstructive sleep apnoea. Sleep Breath. 2016;20(3):903-910.
52. Watanabe T, Isono S, Tanaka A, Tanzawa H, Nishino T. Contribution of body habitus and craniofacial characteristics to segmental closing pressures of the passive pharynx in patients with sleep-disordered breathing. Am J Respir Crit Care Med. 2002;165(2):260-265.
53. Schell TG. Avoiding and Managing Oral Appliance Therapy Side Effects. Sleep Med Clin. 2018;13(4):503-512.
54. Sheats RD ST, Blanton AO,et al. Management of Side Effects of Oral Appliance Therapy for Sleep-Disordered Breathing. J Dent Sleep Med. 2017;4:111–125.

Chapter 4

POLYETHERETHERKETONE(PEEK) IN FIXED PROSTHODONTICS

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INTRODUCTION

Polyetheretherketone (PEEK) polymer is a member of the polyaryletherketone (PAEK) polymer family, which exhibits resistance at temperatures greater than 300°C as well as high mechanical and chemical resistance. PEEK is a semi-crystalline thermoplastic composite polymer comprising two ethers and one ketone monomer. PEEK polymer comprises a repeating ketone molecule and two ether molecules, while poly(oxy-1,4-phenylene-oxy-1,4-phenylene) is highly stable, with a completely aromatic linear structure due to the presence of only carbon (C), hydrogen (H), and oxygen (O) atoms. PEEK polymer exhibits broad applications, besides tissue compatibility, due to its superior chemical and physical stability, i.e., anti-aging behavior. In this manner, PEEK polymer also exhibits resistance against heat and radiation applied during sterilization. The advantages of PEEK, such as high tissue compatibility and low bacterial plaque retention, can further promote its use in dentistry. In addition, microbial biofilm adhesion on the PEEK surface is equal to or less than that on surfaces of restorative materials such as titanium and zirconia. Owing to these promising physical and mechanical properties, PEEK exhibits some advantages over conventional alloys and ceramics. PEEK polymer can resist deformation that may occur due to compression and tension forces originating from one direction as well as withstand compression forces no greater than 1380 N. Studies have reported that PEEK material is durable up to 1200 N. One of the important properties of PEEK polymer is its inert nature. The PEEK polymer cannot dissolve in any conventional solution except for a 98% sulfuric acid solution at room temperature. The PEEK polymer can be used in dental implantology and prosthodontics due to its biomechanical properties, long lifespan, tissue compatibility, and mechanical properties similar to bone tissues (1-8).

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PEEK IN POST-CORE AND TEMPORARY RESTORATIONS

Milled PEEK posts also have been thought to serve as an alternative to glass fiber and cast metal posts. Benli et al. (48) have reported that the tensile bond strength of PEEK posts is greater than those of metal and glass fiber posts when used with an appropriate surface modification and adhesive system. Previous studies have examined the performance of PEEK for CAD-CAM-fabricated implant abutments, customized healing abutments, and temporary crowns (49,50). Abdullah et al. (50) have compared temporary crowns in an in vitro study by using VITA CAD Temp(VITA Zahnfabrik), PEEK(Invibio Biomaterial Company), Telio CAD-Temp(Ivoclar Vivadent), and Protemp4 (3M ESPE). According to the results of this study, CAD-CAM-milled PEEK temporary crowns exhibit a better marginal and internal fit, and fracture strength than those of conventional temporary crowns. Zoidis et al. (28) have reported that after the placement of two titanium implants in the anterior region of the mandible, before permanent restorations during the 4-month healing period, the use of three-unit fixed composite resin veneering PEEK framework temporary prostheses is clinically successful.

CONCLUSION

In previous conducted studies, PEEK is thought to be suitable for implant-or tooth-supported FDPs due to its positive physico-chemical and bio-mechanical properties. However, further experimental and clinical studies are required to safely recommend PEEK as an alternative to rooted prosthetic materials and to evaluate the long-term performance of PEEK FDPs.

REFERENCES

1. Stawarczyk B, Keul C, Beuer F, Roos M, Schmidlin PR. Tensile bond strength of veneering resins to PEEK: impact of different adhesives. Dent Mater J. 2013;32(3):441-8.
2. Gama LT, Duque TM, Özcan M, Philippi AG, Mezzomo LAM, Gonçalves TMSV. Adhesion to high-performance polymers applied in dentistry: A systematic review. Dent Mater. 2020;36(4):e93-e108.
3. Preis V, Hahnel S, Behr M, Bein L, Rosentritt M. In-vitro fatigue and fracture testing of CAD/CAM-materials in implant-supported molar crowns. Dent Mater. 2017;33(4):427-33.
4. Lambert H, Durand JC, Jacquot B, Fages M. Dental biomaterials for chairside CAD/CAM: State of the art. J Adv Prosthodont. 2017;9(6):486-95.
5. Dal Piva AMO, Tribst JPM, Borges ALS, Souza ROAE, Bottino MA. CAD-FEA modeling and analysis of different full crown monolithic restorations. Dent Mater. 2018;34(9):1342–50.
6. Henriques B, Fabris D, Mesquita-Guimarães J, Sousa AC, Hammes N, Souza JCM, Silva FS, Fredel MC. Influence of laser structuring of PEEK, PEEK-GF30 and PEEK-CF30 surfaces on the shear bond strength to a resin cement. J Mech Behav Biomed Mater. 2018;84:225-34.
7. Mishra S, Chowdhary R. PEEK materials as an alternative to titanium in dental implants: A systematic review. Clin Implant Dent Relat Res. 2019;21(1):208-22.
8. Kurtz SM, Devine JN. PEEK biomaterials in trauma, orthopedic, and spinal implants.

Biomaterials. 2007;28(32):4845-69.
9. Niem T, Youssef N, Wöstmann B. Energy dissipation capacities of CAD-CAM restorative materials: A comparative evaluation of resilience and toughness. J Prosthet Dent. 2019;121(1):101-9.
10. Lee WT, Koak JY, Lim YJ, Kim SK, Kwon HB, Kim MJ. Stress shielding and fatigue limits of polyether-ether-ketone dental implants. J Biomed Mater Res B Appl Biomater. 2012;100(4):1044-52.
11. Papathanasiou I, Kamposiora P, Papavasiliou G, Ferrari M. The use of PEEK in digital prosthodontics: A narrative review. BMC Oral Health. 2020;20(1):217. doi: 10.1186/s12903-020-01202-7.
12. Cabello-Domínguez G, Pérez-López J, Veiga-López B, González D, Revilla-León M. Maxillary zirconia and mandibular composite resin-lithium disilicate-modified PEEK fixed implant-supported restorations for a completely edentulous patient with an atrophic maxilla and mandible: A clinical report. J Prosthet Dent. 2020;124(4):403-10.
13. Kanzow P, Wiegand A, Schwendicke F, Göstemeyer G. Same, same, but different? A systematic review of protocols for restoration repair. J Dent. 2019;86:1-16.
14. Schwitalla AD, Bötel F, Zimmermann T, Sütel M, Müller WD. The impact of argon/oxygen low-pressure plasma on shear bond strength between a veneering composite and different PEEK materials. Dent Mater. 2017;33(9):990-4.
15. Çulhaoğlu AK, Özkır SE, Şahin V, Yılmaz B, Kılıçarslan MA. Effect of Various Treatment Modalities on Surface Characteristics and Shear Bond Strengths of Polyetheretherketone-Based Core Materials. J Prosthodont. 2020;29(2):136-41.
16. Caglar I, Ates SM, Yesil Duymus Z. An In Vitro Evaluation of the Effect of Various Adhesives and Surface Treatments on Bond Strength of Resin Cement to Polyetheretherketone. J Prosthodont. 2019;28(1):e342-e349.
17. Ourahmoune R, Salvia M, Mathia TG, Mesrati N. Surface morphology and wettability of sandblasted PEEK and its composites. Scanning. 2014;36(1):64-75.
18. Silthampitag P, Chaijareenont P, Tattakorn K, Banjongprasert C, Takahashi H, Arksornnukit M. Effect of surface pretreatments on resin composite bonding to PEEK. Dent Mater J. 2016;35(4):668-74.
19. Stawarczyk B, Taufall S, Roos M, Schmidlin PR, Lümkemann N. Bonding of composite resins to PEEK: the influence of adhesive systems and air-abrasion parameters. Clin Oral Investig. 2018;22(2):763-71.
20. Bötel F, Zimmermann T, Sütel M, Müller WD, Schwitalla AD. Influence of different low-pressure plasma process parameters on shear bond strength between veneering composites and PEEK materials. Dent Mater. 2018;34(9):e246-e254.
21. Rosentritt M, Preis V, Behr M, Sereno N, Kolbeck C. Shear bond strength between veneering composite and PEEK after different surface modifications. Clin Oral Investig. 2015;19(3):739-44.
22. Jin HY, Teng MH, Wang ZJ, Li X, Liang JY, Wang WX, Jiang S, Zhao BD. Comparative evaluation of BioHPP and titanium as a framework veneered with composite resin for implant-supported fixed dental prostheses. J Prosthet Dent. 2019;122(4):383-8.
23. Younis M, Unkovskiy A, ElAyouti A, Geis-Gerstorfer J, Spintzyk S. The Effect of Various Plasma Gases on the Shear Bond Strength between Unfilled Polyetheretherketone (PEEK) and Veneering Composite Following Artificial Aging. Materials (Basel). 2019 May 4;12(9):1447. doi: 10.3390/ma12091447.
24. Stawarczyk B, Jordan P, Schmidlin PR, Roos M, Eichberger M, Gernet W, Keul C. PEEK surface treatment effects on tensile bond strength to veneering resins. J Prosthet Dent. 2014;112(5):1278-88.
25. Bunz O, Benz CI, Arnold WH, Piwowarczyk A. Shear bond strength of veneering composite to high performance polymers. Dent Mater J. 2020 Oct 20. doi: 10.4012/dmj.2019-300.
26. Sulaya K, Guttal SS. Clinical evaluation of performance of single unit polyetheretherketone

crown restoration-a pilot study. J Indian Prosthodont Soc. 2020;20(1):38-44.
27. Parmigiani-Izquierdo JM, Cabaña-Muñoz ME, Merino JJ, Sánchez-Pérez A. Zirconia implants and peek restorations for the replacement of upper molars. Int J Implant Dent. 2017;3(1):1-5.
28. Zoidis P, Papathanasiou I. Modified PEEK resin-bonded fixed dental prosthesis as an interim restoration after implant placement. J Prosthet Dent. 2016;116(5):637-41.
29. Zoidis P, Bakiri E, Papathanasiou I, Zappi A. Modified PEEK as an alternative crown framework material for weak abutment teeth: a case report. Gen Dent. 2017;65(5):37–40.
30. Raj DA, Chander NG, Reddy JR, Balasubramaniam M. Clinical acceptability of PEEK fixed dental prosthesis in partially edentulous patient- A one year single arm pilot study. J Oral Biol Craniofac Res. 2020;10(4):523-8.
31. Andrikopoulou E, Zoidis P, Artopoulou II, Doukoudakis A. Modified PEEK Resin Bonded Fixed Dental Prosthesis for a Young Cleft Lip and Palate Patient. J Esthet Restor Dent. 2016;28(4):201-7.
32. Tasopoulos T, Pachiou A, Kouveliotis G, Karaiskou G, Ottenga M, Zoidis P. An 8-Year Clinical Outcome of Posterior Inlay Retained Resin Bonded Fixed Dental Prosthesis Utilizing High Performance Polymer Materials: A Clinical Report. J Prosthodont. 2021;30(1):19-23.
33. Stawarczyk B, Beuer F, Wimmer T, Jahn D, Sener B, Roos M, Schmidlin PR. Polyetheretherketone-a suitable material for fixed dental prostheses? J Biomed Mater Res B Appl Biomater. 2013;101(7):1209-16.
34. Liebermann A, Wimmer T, Schmidlin PR, Scherer H, Löffler P, Roos M, Stawarczyk B. Physicomechanical characterization of polyetheretherketone and current esthetic dental CAD/CAM polymers after aging in different storage media. J Prosthet Dent. 2016;115(3):321-8.e2.
35. Taufall S, Eichberger M, Schmidlin PR, Stawarczyk B. Fracture load and failure types of different veneered polyetheretherketone fixed dental prostheses. Clin Oral Investig. 2016;20(9):2493–500.
36. Tartuk BK, Ayna E, Başaran EG. Comparison of The Load-Bearing Capacities of Monolithic PEEK, Zirconia and Hybrid Ceramic Molar Crowns. Meandros Med Dent J. 2019;20:45-50.
37. Nazari V, Ghodsi S, Alikhasi M, Sahebi M, Shamshiri AR. Fracture strength of three-unit implant supported fixed partial dentures with excessive crown height fabricated from different materials. J Dent (Tehran). 2016;13(6):400–6.
38. Waltimo A, Kononen M. A novel bite force recorder and maximal isometric bite force values for healthy young adults. Scand J Dent Res. 1993;101(3):171–5.
39. Elsayed A, Farrag G, Chaar MS, Abdelnabi N, Kern M. Influence of different CAD/CAM crown materials on the fracture of custom-made titanium and zirconia implant abutments after artificial aging. Int J Prosthodont. 2019;32(1):91–6.
40. Beuer F, Steff B, Naumann M, Sorensen JA. Load-bearing capacity of all-ceramic three-unit fixed partial dentures with different computer-aided design (CAD)/computer-aided manufacturing (CAM) fabricated framework materials. Eur J Oral Sci. 2008;116:381–6.
41. Kolbeck C, Behr M, Rosentritt M, Handel G. Fracture force of tooth–tooth-and implant–tooth-supported all-ceramic fixed partial dentures using titanium vs. customized zirconia implant abutments. Clin Oral Implants Res. 2008;19:1049–53.
42. Stawarczyk B, Schmid P, Roos M, Eichberger M, Schmidlin PR. Spectrophotometric evaluation of Polyetheretherketone (PEEK) as a Core material and a comparison with gold standard Core materials. Materials (Basel). 2016;9(6):491.
43. Wimmer T, Huffmann AM, Eichberger M, Schmidlin PR, Stawarczyk B. Two-body wear rate of PEEK, CAD/CAM resin composite and PMMA: effect of specimen geometries, antagonist materials and test set-up configuration. Dent Mater. 2016;32(6):e127–e136.
44. Wachtel A, Zimmermann T, Sütel M, Adali U, Abou-Emara M, Müller WD, Mühlemann S, Schwitalla AD. Bacterial leakage and bending moments of screw-retained, composite-veneered PEEK implant crowns. J Mech Behav Biomed Mater. 2019;91:32-37.
45. Ghodsi S, Zeighami S, Meisami AM. Comparing retention and internal adaptation of different implant-supported, metal-free frameworks. Int J Prosthodont. 2018;31(5):475–7.

46. Zeighami S, Ghodsi S, Sahebi M, Yazarloo S. Comparison of marginal adaptation of different implant-supported metal-free frameworks before and after cementation. Int J Prosthodont. 2019;32(4):361–3.
47. Zoidis P. The all-on-4 modified polyetheretherketone treatment approach: a clinical report. J Prosthet Dent. 2018;119(4):516–21.
48. Benli M, Eker Gümüş B, Kahraman Y, Huck O, Özcan M. Surface characterization and bonding properties of milled polyetheretherketone dental posts. Odontology. 2020. 10.1007/s10266-020-00484-1.
49. Beretta M, Poli PP, Pieriboni S, Tansella S, Manfredini M, Cicciù M, Maiorana C. Peri-Implant Soft Tissue Conditioning by Means of Customized Healing Abutment: A Randomized Controlled Clinical Trial. Materials (Basel). 2019 Sep 19;12(18):3041. doi: 10.3390/ma12183041.
50. Abdullah AO, Tsitrou EA, Pollington S. Comparative in vitro evaluation of CAD/CAM vs conventional provisional crowns. J Appl Oral Sci. 2016;24(3):258–63.

Chapter 5

EFFECT OF HIGH CONCENTRATION PEROXIDE BLEACHING AGENTS ON THE SURFACE PROPERTIES OF COMPOSITE RESTORATIONS

Seher KAYA[1]

INTRODUCTION

Tooth whitening is gaining popularity and acceptability because it produces a pleasing cosmetic impact. It may be used to treat stained teeth with low cost and without causing damage to the enamel and dentine. Bleaching agents effectively whiten teeth, but the effects of this technique on composite resin materials are controversial.[1]

Office type whitening is a treatment method applied by dentists to remove the discoloration of teeth caused by internal and external factors. In office treatments, high concentrations of carbamide peroxide or hydrogen peroxide (30-35%) are applied to the surface of the teeth and left for twenty or thity minutes. This approach involves one to four sessions scheduled 2-4 weeks apart, depending on the product's instructions, and is totally within the clinician's control.[2, 3] The most often used bleaching chemical is hydrogen peroxide (HP).[1]

In-office bleaching agents have high HP concentrations (generally 15 percent to 38 percent), whereas at-home bleaching solutions have HP concentrations ranging from 3% to 10%. [4] Most office bleaching and home bleaching procedures have been found to be successful, but it has been reported that results may vary depending on factors such as the type of stain, the age of the patient, the concentration of the bleaching agent, and the duration and frequency of treatment.[5]

Carbamide peroxide is a very unstable agent, so as soon as it comes into contact with tissue and saliva, one-third converts to hydrogen peroxide and two-thirds to urea. Immediately after, urea also decomposes into ammonia and carbon dioxide molecule.[6] In addition to being an oxidizing agent, hydrogen peroxide is acidic because its pH is quite low. When hydrogen peroxide is applied to the tooth surface, it breaks down into hydroxyl radicals, water and oxygen molecules. Because free

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It has been observed that glass fillers containing barium are more sensitive to water attack than glass fillers containing both quartz and amorphous SiO_2. The microfill particles, on the other hand, have more Si accessible for leaching due to their greater surface areas.[53] Finer glass particles have also been observed to disintegrate faster than coarser glass particles. More interfaces are created as a result of the dissolving, which might impact filler deterioration.[54] In light of all this information, the filler structure is considered to be of primary importance, although other factors, such as filler particle shape, the proportion and size of the largest fillers in composite resins, may play a role in the surface roughness caused by bleaching agents.[3]

Based on data reported in previous studies[34, 37], surface polishing should not be the preferred treatment after bleaching, considering that extensive and irreversible deterioration may have occurred in composite restorations. It is recommended that a composite be completely replaced or repaired after it has been bleached[37]. Since the depth of the changes caused by contact with the bleaching agents has not yet been fully determined, the repair should not be limited to the superficial layer of the composite, but should also cover a portion of the intermediate. It should be noted that it is not possible to restore the roughness of composites to their original values by polishing.

REFERENCES

1. Yu H, Zhang Cy, Wang Yn, Cheng H. Hydrogen peroxide bleaching induces changes in the physical properties of dental restorative materials: Effects of study protocols. *Journal of Esthetic and Restorative Dentistry*. 2018;30(2):E52-E60.
2. Taher NM. The effect of bleaching agents on the surface hardness of tooth colored restorative materials. *J Contemp Dent Pract*. 2005;6(2):18-26.
3. Dogan A, Ozcelik S, Dogan OM, Hubbezoglu I, Cakmak M, Bolayir G. Effect of bleaching on roughness of dental composite resins. *The Journal of Adhesion*. 2008;84(11):897-914.
4. Affairs ADACoS. Tooth whitening/bleaching: treatment considerations for dentists and their patients. *Chicago: ADA*. 2009;
5. Leal A, Paula A, Ramalho A, Esteves M, Ferreira MM, Carrilho E. Roughness and microhardness of composites after different bleaching techniques. *Journal of applied biomaterials & functional materials*. 2015;13(4):381-388.
6. Yap A, Wattanapayungkul P. Effects of in-office tooth whiteners on hardness of tooth-colored restoratives. *Operative Dentistry*. 2002;27(2):137-141.
7. Turker ŞB, Biskin T. Effect of three bleaching agents on the surface properties of three different esthetic restorative materials. *The Journal of prosthetic dentistry*. 2003;89(5):466-473.
8. Park H-J, Kwon T-Y, Nam S-H, Kim H-J, Kim K-H, Kim Y-J. Changes in bovine enamel after treatment with a 30% hydrogen peroxide bleaching agent. *Dental materials journal*. 2004;23(4):517-521.
9. Cengiz E, Kurtulmus-Yilmaz S, Ulusoy N, Deniz ST, Yuksel-Devrim E. The effect of home bleaching agents on the surface roughness of five different composite resins: A SEM evaluation. *Scanning*. 2016;38(3):277-283.
10. Yu H, Li Q, Hussain M, Wang Y. Effects of bleaching gels on the surface microhardness of tooth-colored restorative materials in situ. *Journal of dentistry*. 2008;36(4):261-267.
11. AlQahtani M. The effect of a 10% carbamide peroxide bleaching agent on the microhardness of four types of direct resin-based restorative materials. *Operative dentistry*. 2013;38(3):316-323.

12. Wattanapayungkul P, Yap AU, Chooi KW, Lee M, Selamat RS, Zhou RD. The effect of home bleaching agents on the surface roughness of tooth-colored restoratives with time. *OPERATIVE DENTISTRY-UNIVERSITY OF WASHINGTON-*. 2004;29(4):398-403.
13. Lago M, Mozzaquatro LR, Rodrigues C, Kaizer MR, Mallmann A, Jacques LB. Influence of bleaching agents on color and translucency of aged resin composites. *Journal of Esthetic and Restorative Dentistry*. 2017;29(5):368-377.
14. Hatanaka GR, Abi-Rached FdO, Almeida-Junior AAd, Cruz CAdS. Effect of carbamide peroxide bleaching gel on composite resin flexural strength and microhardness. *Brazilian dental journal*. 2013;24:263-266.
15. Willems G, Celis J-P, Lambrechts P, Braem M, Vanherle G. Hardness and Young's modulus determined by nanoindentation technique of filler particles of dental restorative materials compared with human enamel. *Journal of biomedical materials research*. 1993;27(6):747-755.
16. Yap A, Wee K, Teoh S. Effects of cyclic temperature changes on hardness of composite restoratives. *Operative dentistry*. 2002;27(1):25-29.
17. Oberholzer TG, Grobler SR, Pameijer CH, Hudson AP. The effects of light intensity and method of exposure on the hardness of four light-cured dental restorative materials. *International dental journal*. 2003;53(4):211-215.
18. Vankerckhoven H, Lambrechts P, Van Beylen M, Vanherle G. Materials Science: Characterization of Composite Resins by NMR and TEM. *Journal of dental research*. 1981;60(12):1957-1965.
19. Scougall-Vilchis RJ, Hotta Y, Hotta M, Idono T, Yamamoto K. Examination of composite resins with electron microscopy, microhardness tester and energy dispersive X-ray microanalyzer. *Dental materials journal*. 2009;28(1):102-112.
20. Raptis C, Fan P, Powers J. Properties of microfilled and visible light-cured composite resins. *Journal of the American Dental Association (1939)*. 1979;99(4):631-633.
21. Fontes ST, Fernández MR, Moura CMd, Meireles SS. Color stability of a nanofill composite: effect of different immersion media. *Journal of Applied Oral Science*. 2009;17:388-391.
22. Hannig C, Duong S, Becker K, Brunner E, Kahler E, Attin T. Effect of bleaching on subsurface micro-hardness of composite and a polyacid modified composite. *Dental Materials*. 2007;23(2):198-203.
23. Lima DANL, De Alexandre RS, Martins ACM, Aguiar FHB, Ambrosano GMB, Lovadino JR. Effect of curing lights and bleaching agents on physical properties of a hybrid composite resin. *Journal of Esthetic and Restorative Dentistry*. 2008;20(4):266-273.
24. YAMANEL K, BALTACIOĞLU İ, BAĞIŞ YH. Office bleaching uygulamasının kompozit rezinlerin yüzey sertliğine etkisi.
25. Buergers R, Schneider-Brachert W, Hahnel S, Rosentritt M, Handel G. Streptococcal adhesion to novel low-shrink silorane-based restorative. *Dental materials*. 2009;25(2):269-275.
26. Mourouzis P, Koulaouzidou EA, Helvatjoglu-Antoniades M. Effect of in-office bleaching agents on physical properties of dental composite resins. *Quintessence International*. 2013;44(4)
27. Hegedüs C, Bistey T, Flora-Nagy E, Keszthelyi G, Jenei A. An atomic force microscopy study on the effect of bleaching agents on enamel surface. *Journal of dentistry*. 1999;27(7):509-515.
28. Wattanapayungkul P, Yap A. Effects of in-office bleaching products on surface finish of tooth-colored restorations. *Operative dentistry*. 2003;28(1):15-19.
29. Yu H, Li Q, Cheng H, Wang Y. The effects of temperature and bleaching gels on the properties of tooth-colored restorative materials. *The Journal of prosthetic dentistry*. 2011;105(2):100-107.
30. Cooley RL, Burger KM. Effect of carbamide peroxide on composite resins. *Quintessence International*. 1991;22(10)
31. Pecho OE, Martos J, Pinto KV, Pinto KV, Baldissera RA. Effect of hydrogen peroxide on color and whiteness of resin-based composites. *Journal of Esthetic and Restorative Dentistry*. 2019;31(2):132-139.
32. Dietschi D, Campanile G, Holz J, Meyer J-M. Comparison of the color stability of ten new-generation composites: an in vitro study. *Dental Materials*. 1994;10(6):353-362.
33. Wang L, Francisconi LF, Atta MT, et al. Effect of bleaching gels on surface roughness of nanofilled composite resins. *European journal of dentistry*. 2011;5(02):173-179.

34. Mendes APKF, Barceleiro MdO, Reis RSaAd, Bonato LL, Dias KRHC. Changes in surface roughness and color stability of two composites caused by different bleaching agents. *Brazilian dental journal*. 2012;23(6):659-666.
35. Torres C, Ribeiro C, Bresciani E, Borges AB. Influence of hydrogen peroxide bleaching gels on color, opacity, and fluorescence of composite resins. *Operative dentistry*. 2012;37(5):526-531.
36. Rao YM, Srilakshmi V, Vinayagam KK, Narayanan LL. An evaluation of the color stability of tooth-colored restorative materials after bleaching using CIELAB color technique. *Indian Journal of Dental Research*. 2009;20(1):60.
37. Yalcin F, Gürgan S. Effect of two different bleaching regimens on the gloss of tooth colored restorative materials. *Dental Materials*. 2005;21(5):464-468.
38. Hubbezoglu I, Akaoglu B, Dogan A, et al. Effect of bleaching on color change and refractive index of dental composite resins. *Dental materials journal*. 2008;27(1):105-116.
39. Joiner A. The bleaching of teeth: a review of the literature. *Journal of dentistry*. 2006;34(7):412-419.
40. Pecho OE, Ghinea R, do Amaral EAN, Cardona JC, Della Bona A, Pérez MM. Relevant optical properties for direct restorative materials. *Dental Materials*. 2016;32(5):e105-e112.
41. Rosentritt M, Lang R, Plein T, Behr M, Handel G. Discoloration of restorative materials after bleaching application. *Quintessence international*. 2005;36(1)
42. Canay Ş, Çehreli MC. The effect of current bleaching agents on the color of light-polymerized composites in vitro. *The Journal of prosthetic dentistry*. 2003;89(5):474-478.
43. Yap A, Wattanapayungkul P, Chung S. Influence of the polymerization process on composite resistance to chemical degradation by food-simulating liquids. *Operative dentistry*. 2003;28(6):723-727.
44. Correr GM, Alonso RCB, Sobrinho LC, Puppin-Rontani RM, Ferracane JL. In vitro wear of resin-based materials—Simultaneous corrosive and abrasive wear. *Journal of Biomedical Materials Research Part B: Applied Biomaterials: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials*. 2006;78(1):105-114.
45. Markovic L, Jordan RA, Glasser M-C, et al. Effects of bleaching agents on surface roughness of filling materials. *Dental materials journal*. 2014;33(1):59-63.
46. Gladys S, Van Meerbeek B, Braem M, Lambrechts P, Vanherle G. Comparative physico-mechanical characterization of new hybrid restorative materials with conventional glass-ionomer and resin composite restorative materials. *Journal of Dental Research*. 1997;76(4):883-894.
47. Moraes RR, Marimon JL, Schneider LF, Correr Sobrinho L, Camacho GB, Bueno M. Carbamide peroxide bleaching agents: effects on surface roughness of enamel, composite and porcelain. *Clin Oral Investig*. Mar 2006;10(1):23-8. doi:10.1007/s00784-005-0016-1
48. Bahari M, Chaharom MEE, Daneshpooy M, Gholizadeh S, Pashayi H. Effect of bleaching protocols on surface roughness and biofilm formation on silorane-based composite resin. *Dental research journal*. 2019;16(4):264.
49. Hasegawa H, Tomiyama K, Kumada H, et al. Antimicrobial effects of carbamide peroxide against a polymicrobial biofilm model. *American journal of dentistry*. 2015;28:57-60.
50. Ke-yong Y, Rui M, Ming-yu L, Zhi-yan H, Wei Z. The efficacy of cold-light tooth bleaching on the formation of bacteria biofilm on the enamel surfaces. *Shanghai Journal of Stomatology*. 2015;24(3):283.
51. Langsten RE, Dunn WJ, Hartup GR, Murchison DF. Higher-concentration carbamide peroxide effects on surface roughness of composites. *Journal of Esthetic and Restorative Dentistry*. 2002;14(2):92-96.
52. Basting RT, Y FERNANDÉZ CF, Ambrosano GMB, de Campos IT. Effects of a 10% carbamide peroxide bleaching agent on roughness and microhardness of packable composite resins. *Journal of Esthetic and Restorative Dentistry*. 2005;17(4):256-262.
53. Soderholm K-J. Leaking of fillers in dental composites. *Journal of Dental Research*. 1983;62(2):126-130.
54. Kalachandra S. Influence of fillers on the water sorption of composites. *Dental Materials*. 1989;5(4):283-288.

Chapter 6

AUTOLOGOUS PLATELET CONCENTRATES: THEIR GENERATIONS, FORMS, PREPARATION PROTOCOLS AND ROLES IN PERIODONTAL REGENERATION

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INTRODUCTION

Periodontitis is a complex, multifactorial inflammatory disease characterized by loss of connective tissue attachment and destruction of alveolar bone, cementum, periodontal ligament and gingiva as a response to inflammation stimulated by microbial accumulations [1]. This leads to the initiation of periodontal defects[2]. Periodontal defects are divided into suprabony pocket and intrabony pocket. Intrabony pocket is a pocket with a base of sulcus that is more apical than alveolar bone, which generally indicates a vertical or angular defect. Suprabony pocket is a pocket with a base of sulcus more coronal or at the same level with alveolar bone[3].

Treatment of periodontitis includes surgical and non-surgical treatment[4], where surgical treatment is performed if inflammation persists after non-surgical treatment[5]. One of the periodontal surgical treatments is an Open Flap Debridement (OFD) (fig. 1) which aims to removing infection and inflamed tissue[6].

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Table (1) : Centrifugation Protocols of Platelet Concentrates			
Platelet Concentrate Type		Centrifugation Protocol	
Platelet-Rich Plasma (PRP)	Whole blood	(first soft spin) 1200 rpm	12 min
	Plasma	(second hard spin) 3300 rpm	7 min
Platelet-Rich Fibrin (PRF) or (L-PRF)		2700-3000 rpm	12 min
Injectable Platelet-Rich Fibrin (i-PRF)		700-800 rpm	3-4 min
Advanced Platelet-Rich Fibrin (A-PRF)		1500 rpm	14 min
Titanium Platelet-Rich Fibrin (T-PRF)		2700 rpm	12 min
Concentrated Growth Factor (CGF)		2700-2400-2700-3000 rpm	2-4-4-3 min

CONCLUSIONS

PRF has productive results in healing and regeneration. Therefore, it has wide clinical applications in all treatments wherever regeneration is required. The use of autologous platelet concentrates in treatment is acceptable by patients for some reasons where the sample is taken from the patient so there is no risk of infection, no cost is needed, and lesser discomfort suffered by patients. There are some forms of PRF which can be obtained by changing the centrifugation speed and time and all of them have wide applications in periodontology and implant dentistry due to their containing leukocytes, platelets, and growth factors which have regenerative effects on hard and soft tissue healing. It has been proved that all forms of PRF are more efficient in the regeneration treatment than PRP which almost has been eliminated from current clinical applications due to its complicated and long preparation protocol; and because it needs anticoagulant and inadequate regeneration capacity compared to PRF. Since PRF has promising results, further researches are also needed to find more different formulations which have more advantages than the ones currently used.

REFERENCES

1. Mani R, Mahantesha S, Nandini TK, Lavanya R. Growth Factors in Periodontal Regeneration. *J Adv Oral Res*. 2014;5(2):1-5. doi:10.1177/2229411220140201
2. Newman, Michael G., Takei, Henry H., Klokkevold PR. Newman and Carranza's Clinical Periodontology Thirteenth Edition. Journal of Chemical Information and Modeling. Published 2017. Accessed December 9, 2020.
3. Bosshardt DD. The periodontal pocket: pathogenesis, histopathology and consequences. *Periodontol 2000*. 2018;76(1):43-50. doi:10.1111/prd.12153

4. Kanoriya D, Pradeep AR, Singhal S, Garg V, Guruprasad CN. Synergistic Approach Using Platelet-Rich Fibrin and 1% Alendronate for Intrabony Defect Treatment in Chronic Periodontitis: A Randomized Clinical Trial. *J Periodontol*. 2016;87(12):1427-1435. doi:10.1902/jop.2016.150698
5. Heitz-Mayfield LJA, Lang NP. Surgical and nonsurgical periodontal therapy. Learned and unlearned concepts. *Periodontol 2000*. 2013;62(1):218-231. doi:10.1111/prd.12008
6. Martande SS, Kumari M, Pradeep AR, Singh SP, Suke DK, Guruprasad CN. Platelet-Rich Fibrin Combined With 1.2% Atorvastatin for Treatment of Intrabony Defects in Chronic Periodontitis: A Randomized Controlled Clinical Trial. *J Periodontol*. 2016;87(9):1039-1046. doi:10.1902/jop.2016.150306
7. Cortellini P, Tonetti MS. Clinical concepts for regenerative therapy in intrabony defects. *Periodontol 2000*. 2015;68(1):282-307. doi:10.1111/prd.12048
8. Chadwick JK, Mills MP, Mealey BL. Clinical and Radiographic Evaluation of Demineralized Freeze-Dried Bone Allograft Versus Platelet-Rich Fibrin for the Treatment of Periodontal Intrabony Defects in Humans. *J Periodontol*. 2016;87(11):1253-1260. doi:10.1902/jop.2016.160309
9. Crespi R, Capparè P, Gherlone E. Magnesium-Enriched Hydroxyapatite Compared to Calcium Sulfate in the Healing of Human Extraction Sockets: Radiographic and Histomorphometric Evaluation at 3 Months. *J Periodontol*. 2009;80(2):210-218. doi:10.1902/jop.2009.080400
10. Alpiste Illueca FM, Buitrago Vera P, de Grado Cabanilles P, Fuenmayor Fernandez V, Gil Loscos FJ. *Periodontal Regeneration in Clinical Practice*. Vol 11.; 2006.
11. Gawaz M, Vogel S. Platelets in tissue repair: Control of apoptosis and interactions with regenerative cells. *Blood*. 2013;122(15):2550-2554. doi:10.1182/blood-2013-05-468694
12. Ehrenfest DMD, Sammartino G, Shibli JA, Wang H, Zou D, Bernard J. Guidelines for the publication of articles related to platelet concentrates (Platelet-Rich Plasma - PRP , or Platelet-Rich Fibrin - PRF): the international classification of the POSEIDO. POSEIDO Journal. Published 2013. Accessed December 9, 2020. https://www.researchgate.net/publication/285762930_Guidelines_for_the_publication_of_articles_related_to_platelet_concentrates_Platelet-Rich_Plasma_-_PRP_or_Platelet-Rich_Fibrin_-_PRF_The_international_classification_of_the_POSEIDO
13. Dohan DM, Choukroun J, Diss A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part I: Technological concepts and evolution. *Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology*. 2006;101(3). doi:10.1016/j.tripleo.2005.07.008
14. Dohan Ehrenfest DM, Rasmusson L, Albrektsson T. Classification of platelet concentrates: from pure platelet-rich plasma (P-PRP) to leucocyte- and platelet-rich fibrin (L-PRF). *Trends Biotechnol*. 2009;27(3):158-167. doi:10.1016/j.tibtech.2008.11.009
15. Choukroun J, Diss A, Simonpieri A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part V: Histologic evaluations of PRF effects on bone allograft maturation in sinus lift. *Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology*. 2006;101(3):299-303. doi:10.1016/j.tripleo.2005.07.012
16. Kiran NK, Mukunda KS, Tilak Raj TN. Platelet Concentrates: A Promising Innovation In Dentistry. Journal of Dental Sciences and Research. Published 2011. Accessed December 9, 2020. https://www.yumpu.com/en/document/view/31297865/platelet-concentrates-a-promising-innovation-in-ssdctumkurorg
17. Casati MZ, de Vasconcelos Gurgel BC, Gonçalves PF, et al. Platelet-rich plasma does not improve bone regeneration around peri-implant bone defects-A pilot study in dogs. *Int J Oral*

Maxillofac Surg. 2007;36(2):132-136. doi:10.1016/j.ijom.2006.06.004

18. Dohan Ehrenfest DM, de Peppo GM, Doglioli P, Sammartino G. Slow release of growth factors and thrombospondin-1 in Choukroun's platelet-rich fibrin (PRF): A gold standard to achieve for all surgical platelet concentrates technologies. *Growth Factors*. 2009;27(1):63-69. doi:10.1080/08977190802636713
19. Fujioka-Kobayashi M, Miron RJ, Hernandez M, Kandalam U, Zhang Y, Choukroun J. Optimized Platelet-Rich Fibrin With the Low-Speed Concept: Growth Factor Release, Biocompatibility, and Cellular Response. *J Periodontol*. 2017;88(1):112-121. doi:10.1902/jop.2016.160443
20. Preeja C, Arun S. Platelet-rich fibrin: Its role in periodontal regeneration. *Saudi J Dent Res*. 2014;5(2):117-122. doi:10.1016/j.ksujds.2013.09.001
21. Raja S, Byakod G, Pudakalkatti P. Growth factors in periodontal regeneration. *Int J Dent Hyg*. 2009;7(2):82-89. doi:10.1111/j.1601-5037.2009.00380.x
22. Gassling V, Douglas T, Warnke PH, Açil Y, Wiltfang J, Becker ST. Platelet-rich fibrin membranes as scaffolds for periosteal tissue engineering. *Clin Oral Implants Res*. 2010;21(5):543-549. doi:10.1111/j.1600-0501.2009.01900.x
23. Gupta V, Bains V, Singh G, Mathur A, Bains R. Regenerative potential of platelet rich fibrin in dentistry: literature review. Asian J Oral Health Allied Sci. Published 2011. Accessed December 9, 2020.
24. Aroca S, Keglevich T, Barbieri B, Gera I, Etienne D. Clinical Evaluation of a Modified Coronally Advanced Flap Alone or in Combination With a Platelet-Rich Fibrin Membrane for the Treatment of Adjacent Multiple Gingival Recessions: A 6-Month Study. *J Periodontol*. 2009;80(2):244-252. doi:10.1902/jop.2009.080253
25. Kim SG, Kim WK, Park JC, Kim HJ. A comparative study of osseointegration of avana implants in a demineralized freeze-dried bone alone or with platelet-rich plasma. *J Oral Maxillofac Surg*. 2002;60(9):1018-1025. doi:10.1053/joms.2002.34413
26. Marx RE, Carlson ER, Eichstaedt RM, Schimmele SR, Strauss JE, Georgeff KR. Platelet-rich plasma: Growth factor enhancement for bone grafts. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1998;85(6):638-646. doi:10.1016/S1079-2104(98)90029-4
27. Tara L Aghaloo, Peter K Moy EGF. Investigation of platelet-rich plasma in rabbit cranial defects: A pilot study. *J Oral Maxillofac Surg*. 2002;60(10):1176-1181. doi:10.1053/joms.2002.34994
28. Dohan DM, Del Corso M, Charrier JB. Cytotoxicity analyses of Choukroun's platelet-rich fibrin (PRF) on a wide range of human cells: The answer to a commercial controversy. *Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology*. 2007;103(5):587-593. doi:10.1016/j.tripleo.2007.03.016
29. Li A, Yang H, Zhang J, Chen S, Wang H, Gao Y. Additive effectiveness of autologous platelet-rich fibrin in the treatment of intrabony defects: A PRISMA-compliant meta-analysis. *Medicine (Baltimore)*.2019;98(11):e14759. doi:10.1097/MD.0000000000014759
30. Pradeep AR, Rao NS, Agarwal E, Bajaj P, Kumari M, Naik SB. Comparative Evaluation of Autologous Platelet-Rich Fibrin and Platelet-Rich Plasma in the Treatment of 3-Wall Intrabony Defects in Chronic Periodontitis: A Randomized Controlled Clinical Trial. *J Periodontol*. 2012;83(12):1499-1507. doi:10.1902/jop.2012.110705
31. Chang YC, Zhao JH. Effects of platelet-rich fibrin on human periodontal ligament fibroblasts and application for periodontal infrabony defects. *Aust Dent J*. 2011;56(4):365-371. doi:10.1111/j.1834-7819.2011.01362.x
32. Molly L, Quirynen M, Michiels K, Van Steenberghe D. Comparison between jaw bone augmen-

tation by means of a stiff occlusive titanium membrane or an autologous hip graft: A retrospective clinical assessment. *Clin Oral Implants Res*. 2006;17(5):481-487. doi:10.1111/j.1600-0501.2006.01286.x

33. Ghanaati S, Booms P, Orlowska A, et al. Advanced platelet-rich fibrin: A new concept for cell-Based tissue engineering by means of inflammatory cells. *J Oral Implantol*. 2014;40(6):679-689. doi:10.1563/aaid-joi-D-14-00138
34. Miron RJ, Fujioka-Kobayashi M, Hernandez M, et al. Injectable platelet rich fibrin (i-PRF): opportunities in regenerative dentistry? *Clin Oral Investig*. 2017;21(8):2619-2627. doi:10.1007/s00784-017-2063-9
35. Kobayashi E, Flückiger L, Fujioka-Kobayashi M, et al. Comparative release of growth factors from PRP, PRF, and advanced-PRF. *Clin Oral Investig*. 2016;20(9):2353-2360. doi:10.1007/s00784-016-1719-1
36. Rinaldi S, Bussa M, Mascaro A. Update on the treatment of androgenetic alopecia. European Review for Medical and Pharmacological Sciences. Published 2016. Accessed December 10, 2020. https://pubmed.ncbi.nlm.nih.gov/26813453/
37. Tunali M, Özdemir H, Küçükodaci Z, Akman S, Firatli E. In vivo evaluation of titanium-prepared platelet-rich fibrin (T-PRF): A new platelet concentrate. *Br J Oral Maxillofac Surg*. 2013;51(5):438-443. doi:10.1016/j.bjoms.2012.08.003
38. Breme HJ, Biehl V, Helsen JA. "Metals and implants," in Metals as Biomaterials, ed. by J. A. Helsen and H. J. Breme. JohnWiley & Sons, Chichester, UK.
39. J. B. Park. "Metallic biomaterials," in The Biomedical Engineering Handbook, ed. by J. D. Bronzino. CRC Press, Boca Raton, Fla, USA.
40. Takemoto S, Yamamoto T, Tsuru K, Hayakawa S, Osaka A, Takashima S. Platelet adhesion on titanium oxide gels: Effect of surface oxidation. *Biomaterials*. 2004;25(17):3485-3492. doi:10.1016/j.biomaterials.2003.10.070
41. Tukaram Kshirsagar Professor J, Post Graduate Student RS, Rubine Post Graduate Student CS, Tukaram Kshirsagar J. Innovation in regeneration – Concentrated growth factor. *Int J Appl Dent Sci IJADS*. 2017;3(32):206-208.
42. Dong-Seok Sohn. The Use of Concentrated Growth Factors As Alternative To Bone Substitutes For Sinus Augmentation. DENTAL INC. Published 2009. Accessed December 10, 2020.
43. Cochran DL, Schenk R, Buser D, Wozney JM, Jones AA. Recombinant Human Bone Morphogenetic Protein-2 Stimulation of Bone Formation Around Endosseous Dental Implants. *J Periodontol*. 1999;70(2):139-150. doi:10.1902/jop.1999.70.2.139
44. He L, Lin Y, Hu X, Zhang Y, Wu H. A comparative study of platelet-rich fibrin (PRF) and platelet-rich plasma (PRP) on the effect of proliferation and differentiation of rat osteoblasts in vitro. *Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology*. 2009;108(5):707-713. doi:10.1016/j.tripleo.2009.06.044
45. Miron RJ, Fujioka-Kobayashi M, Bishara M, Zhang Y, Hernandez M, Choukroun J. Platelet-Rich Fibrin and Soft Tissue Wound Healing: A Systematic Review. *Tissue Eng - Part B Rev*. 2017;23(1):83-99. doi:10.1089/ten.teb.2016.0233
46. A.M. Everts P, M. Hoogbergen M, A.Weber T, J.J. Devilee R, van Monftort G, H.J.T. de Hingh I. Is the Use of Autologous Platelet-Rich Plasma Gels in Gynecologic, Cardiac, and General, Reconstructive Surgery Beneficial? *Curr Pharm Biotechnol*. 2012;13(7):1163-1172. doi:10.2174/138920112800624346
47. Reynolds MA, Kao RT, Camargo PM, et al. Periodontal Regeneration – Intrabony Defects: A Consensus Report From the AAP Regeneration Workshop. *J Periodontol*. 2015;86(2-s):S105-S107. doi:10.1902/jop.2015.140378

48. Ivanovski S. Periodontal regeneration. *Aust Dent J*. 2009;54:S118-S128. doi:10.1111/j.1834-7819.2009.01150.x
49. Choukroun J, Diss A, Simonpieri A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part IV: Clinical effects on tissue healing. *Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology*. 2006;101(3). doi:10.1016/j.tripleo.2005.07.011
50. Anitua EA. Enhancement of osseointegration by generating a dynamic implant surface. *J Oral Implantol*. 2006;32(2):72-76. doi:10.1563/736.1
51. Fontana S, Olmedo DG, Linares JA, Guglielmotti MB, Crosa ME. Effect of platelet-rich plasma on the peri-implant bone response: An experimental study. *Implant Dent*. 2004;13(1):73-78. doi:10.1097/01.ID.0000116455.68968.29
52. Soni R, Priya A, Yadav H, Mishra N, Kumar L. Bone augmentation with sticky bone and platelet-rich fibrin by ridge-split technique and nasal floor engagement for immediate loading of dental implant after extracting impacted canine. *Natl J Maxillofac Surg*. 2019;10(1):98. doi:10.4103/njms.njms_37_18
53. Borie E, Oliví DG, Orsi IA, et al. Platelet-rich fibrin application in dentistry: A literature review. *Int J Clin Exp Med*. 2015;8(5):7922-7929. Accessed December 10, 2020.
54. Park HC, Kim SG, Oh JS, et al. Early bone formation at a femur defect using CGF and PRF grafts in adult dogs: A comparative study. *Implant Dent*. 2016;25(3):387-393. doi:10.1097/ID.0000000000000423
55. Pirpir C, Yilmaz O, Candirli C, Balaban E. Evaluation of effectiveness of concentrated growth factor on osseointegration. *Int J Implant Dent*. 2017;3(1). doi:10.1186/s40729-017-0069-3
56. Dhurat R, Sukesh M. Principles and methods of preparation of platelet-rich plasma: A review and author's perspective. *J Cutan Aesthet Surg*. 2014;7(4):189. doi:10.4103/0974-2077.150734
57. Dohan Ehrenfest DM, Del Corso M, Diss A, Mouhyi J, Charrier J-B. Three-Dimensional Architecture and Cell Composition of a Choukroun's Platelet-Rich Fibrin Clot and Membrane. *J Periodontol*. 2010;81(4):546-555. doi:10.1902/jop.2009.090531
58. Nelson R, Andy T, Ana C SC. Guidelines for the use of L-PRF Flow Charts: Step by Step Approach Leucocytes and Platelet Rich Fibrin in Different Intra-oral Applications Applying the IntraSpin ™ Concept. researchgate.
59. Nunes CR, Roedersheimer MT, Simske SJ, Luttges MW. Effect of microgravity, temperature, and concentration on fibrin and collagen assembly. Microgravity science and technology. Published 1995. Accessed December 10, 2020.
60. Miron RJ, Chai J, Zhang P, et al. A novel method for harvesting concentrated platelet-rich fibrin (C-PRF) with a 10-fold increase in platelet and leukocyte yields. *Clin Oral Investig*. 2020;24(8):2819-2828. doi:10.1007/s00784-019-03147-w

Chapter 7

EFFECTIVENESS OF ADDITIONAL FILES COMPARED WITH ROTARY AND RESIPROCAL SYSTEMS IN ENDODONTIC RETREATMENT: A MICRO-CT STUDY

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INTRODUCTION

Endodontic treatment involves removing bacteria from the root canal, and completely filling it with nontoxic sealing material to avoid reinfection. However, root canal treatment sometimes fails, and the initial canal sealing may need to be removed for a variety of reasons, such as procedural errors, reinfection of the root canal caused by apical or coronal leakage, insufficient preparation or inadequate canal filling [1, 2]. The complete removal of the initial sealing material is among the essential steps for retreatment success [3]. Many different methods, including K or H endodontic-heated files or chemical solvents, nickel-titanium (Ni-Ti) rotary or reciprocating files, ultrasonic devices, as well as lasers have been employed to remove the initial canal sealing [4-7]. In previous studies, the initial filling materials could not be completely removed using retreatment instruments alone [6,7,8]. Therefore, the use of additional methods (such as different NiTi systems) has been proposed to remove filling materials more effectively [7].

The ProTaper Universal retreatment rotary files (PTUR, Dentsply Maillefer, Ballaigues, Switzerland) was specifically developed to remove canal sealing materials D1 (30 / 0.09), D2 (25 / 0.08) and D3 (20 / 0.07) instruments form the PTUR file system [6]. However, previous studies revealed that the retreatment procedure in a complicated root canal anatomy would be challenging, primarily due to its round design of retreatment file systems [9-14]. Thus, the use of supplementary

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the results by the current study, since the XP-endo shaper has the same file design and apical size as XPR files.

In previous studies, Ni-Ti files with a reciprocating mode were evaluated for retreatment [6, 8, 19]. The reciprocating movement was the most rapid technique for removing initial root canal filling, compared to the hand file and rotary technique [6, 19]. Rios et al. showed that reciprocating systems (the Reciproc Blue and WaveOne Gold) were as effective as the PTUR system in removing old sealing materials from human maxillary incisors root canals [6]. Crozeta et al. also emphasized that PTUR files were equally effective in removal of filling material, compared to both the RB and WaveOne [8]. In addition, Romeiro et al. reported that that the effectiveness of Reciproc and RB was very high in retreatment cases filled either with a bioceramic or resin based sealer [28]. In the present study, both the RB and WOG systems had the same capacity to remove filling materials as the PTUR system. This result is in line with that by Rios et al. and Crozeta et al. Therefore, the amount of filling material removed can be explained by the characteristics of the cross-section design of Ni-Ti systems that make reciprocating movements [6, 8].

CONCLUSION

Although this in vitro study has some limitations, the RB and WOG were found to be as effective as the PTUR. The amount of residual filling materials was the least in the PTU R+ XPR group, but the initial filling material could not be completely removed in any retreatment group in this study.

REFERENCES

1. Wourms DJ, Campbell AD, Hicks ML, Pelleu GB, Jr. Alternative solvents to chloroform for gutta-percha removal. J Endod. 1990; 16(5): 224-6. doi.org/10.1016/s0099-2399(06)81675-4
2. Saunders WP, Saunders EM. Comparison of three instruments in the preparation of the curved root canal using the modified double-flared technique. J Endod. 1994; 20(9): 440-4. doi.org/10.1016/s0099-2399(06)80034-8
3. Ezzie E, Fleury A, Solomon E, Spears R, He J. Efficacy of retreatment techniques for a resin-based root canal obturation material. J Endod. 2006; 32(4): 341-4. doi.org/10.1016/j.joen.2005.09.010
4. Viducic D, Jukic S, Karlovic Z, Bozic Z, Miletic I, Anic I. Removal of gutta-percha from root canals using an Nd:YAG laser. Int Endod J. 2003; 36(10): 670-3. doi.org/10.1046/j.1365-2591.2003.00710.x
5. Gordon MP. The removal of gutta-percha and root canal sealers from root canals. N Z Dent J. 2005; 101(2): 44-52.
6. Rios Mde A, Villela AM, Cunha RS et al. Efficacy of 2 reciprocating systems compared with a rotary retreatment system for gutta-percha removal. J Endod. 2014; 40: 543-6. doi.org/10.1016/j.joen.2013.11.013
7. Yuruker S, Gorduysus M, Kucukkaya S et al. Efficacy of Combined Use of Different Nickel-Titanium Files on Removing Root Canal Filling Materials. J Endod. 2016; 42(3): 487-92. doi.org/10.1016/j.joen.2015.11.019
8. Crozeta BM, Silva-Sousa YT, Leoni GB et al. Micro-Computed Tomography Study of Filling

Material Removal from Oval-shaped Canals by Using Rotary, Reciprocating, and Adaptive Motion Systems. J Endod. 2016; 42(5): 793-7. doi.org/10.1016/j.joen.2016.02.005
9. Machado AG, Guilherme BPS, Provenzano JC et al. Effects of preparation with the Self-Adjusting File, TRUShape and XP-endo Shaper systems, and a supplementary step with XP-endo Finisher R on filling material removal during retreatment of mandibular molar canals. Int Endod J. 2019; 52(5): 709-15. doi.org/10.1111/iej.13039
10. Keleş A, Alcin H, Kamalak A, Versiani MA. Oval-shaped canal retreatment with self-adjusting file: a micro-computed tomography study. Clin Oral Investig. 2014; 18(4): 1147-53. doi.org/10.1007/s00784-013-1086-0
11. Fruchi Lde C, Ordinola-Zapata R, Cavenago BC, Hungaro Duarte MA, Bueno CE, De Martin AS. Efficacy of reciprocating instruments for removing filling material in curved canals obturated with a single-cone technique: a micro-computed tomographic analysis. J Endod. 2014; 40(7): 1000-4. doi.org/10.1016/j.joen.2013.12.011
12. Rodrigues CT, Duarte MA, de Almeida MM, de Andrade FB, Bernardineli N. Efficacy of CM-Wire, M-Wire, and Nickel-Titanium Instruments for Removing Filling Material from Curved Root Canals: A Micro-Computed Tomography Study. J Endod. 2016; 42(11): 1651-5. doi.org/10.1016/j.joen.2016.08.012
13. de Siqueira Zuolo A, Zuolo ML, da Silveira Bueno CE, Chu R, Cunha RS. Evaluation of the Efficacy of TRUShape and Reciproc File Systems in the Removal of Root Filling Material: An Ex Vivo Micro-Computed Tomographic Study. J Endod. 2016; 42(2): 315-9. doi.org/10.1016/j.joen.2015.11.005
14. Rodig T, Reicherts P, Konietschke F, Dullin C, Hahn W, Hulsmann M. Efficacy of reciprocating and rotary NiTi instruments for retreatment of curved root canals assessed by micro-CT. Int Endod J. 2014; 47(10): 942-8. doi.org/10.1111/iej.12239
15. Bernardes RA, Duarte MAH, Vivan RR, Alcalde MP, Vasconcelos BC, Bramante CM. Comparison of three retreatment techniques with ultrasonic activation in flattened canals using micro-computed tomography and scanning electron microscopy. Int Endod J. 2016; 49(9): 890-7. doi.org/10.1111/iej.12522
16. Jiang S, Zou T, Li D, Chang JW, Huang X, Zhang C. Effectiveness of Sonic, Ultrasonic, and Photon-Induced Photoacoustic Streaming Activation of NaOCl on Filling Material Removal Following Retreatment in Oval Canal Anatomy. Photomed Laser Surg. 2016; 34(1): 3-10. doi.org/10.1089/pho.2015.3937
17. Solomonov M, Paque F, Kaya S, Adiguzel O, Kfir A, Yigit-Ozer S. Self-adjusting files in retreatment: a high-resolution micro-computed tomography study. J Endod. 2012; 38(9): 1283-7. doi.org/10.1016/j.joen.2012.06.019
18. Silva E, Belladonna FG, Zuolo AS et al. Effectiveness of XP-endo Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study. Int Endod J. 2018(1); 51: 86-91. doi.org/10.1111/iej.12788
19. Zuolo AS, Mello JE, Jr., Cunha RS, Zuolo ML, Bueno CE. Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. Int Endod J. 2013; 46(10): 947-53. doi.org/10.1111/iej.12085
20. Keskin C, Inan U, Demiral M, Keles A. Cyclic Fatigue Resistance of Reciproc Blue, Reciproc, and WaveOne Gold Reciprocating Instruments. J Endod. 2017; 43(8): 1360-3. doi.org/10.1016/j.joen.2017.03.036
21. De-Deus G, Silva EJ, Vieira VT et al. Blue Thermomechanical Treatment Optimizes Fatigue Resistance and Flexibility of the Reciproc Files. J Endod. 2017; 43(3): 462-6. doi.org/10.1016/j.joen.2016.10.039
22. Stabholz A, Friedman S. Endodontic retreatment--case selection and technique. Part 2: Treatment planning for retreatment. J Endod. 1988(12); 14: 607-14. doi.org/10.1016/s0099-2399(88)80058-x
23. Barletta FB, Rahde Nde M, Limongi O, Moura AA, Zanesco C, Mazocatto G. In vitro comparative analysis of 2 mechanical techniques for removing gutta-percha during retreatment. J Can Dent Assoc. 2007; 73(1): 65.
24. Kfir A, Tsesis I, Yakirevich E, Matalon S, Abramovitz I. The efficacy of five techniques for removing root filling material: microscopic versus radiographic evaluation. Int Endod J. 2012;

45(1): 35-41. doi.org/10.1111/j.1365-2591.2011.01944.x
25. Marques da Silva B, Baratto-Filho F, Leonardi DP, Henrique Borges A, Volpato L, Branco Barletta F. Effectiveness of ProTaper, D-RaCe, and Mtwo retreatment files with and without supplementary instruments in the removal of root canal filling material. Int Endod J. 2012; 45(10): 927-32. doi.org/10.1111/j.1365-2591.2012.02051.x
26. Alves FR, Marceliano-Alves MF, Sousa JC, Silveira SB, Provenzano JC, Siqueira JF, Jr. Removal of Root Canal Fillings in Curved Canals Using Either Reciprocating Single- or Rotary Multi-instrument Systems and a Supplementary Step with the XP-Endo Finisher. J Endod. 2016; 42(7): 1114-9. doi.org/10.1016/j.joen.2016.04.007
27. De-Deus G, Belladonna FG, Zuolo AS et al. 3-dimensional Ability Assessment in Removing Root Filling Material from Pair-matched Oval-shaped Canals Using Thermal-treated Instruments. J Endod. 2019; 45(9): 1135-41. doi.org/10.1016/j.joen.2019.06.003
28. Romeiro K, de Almeida A, Cassimiro M et al. Reciproc and Reciproc Blue in the removal of bioceramic and resin-based sealers in retreatment procedures. Clin Oral Investig. 2020; 24(1): 405-16. doi.org/10.1007/s00784-019-02956-3

Chapter 8

POSTOPERATIVE PAIN FOLLOWING ENDODONTICS

Yelda ERDEM HEPSENOGLU[1]

INTRODUCTION

Pain, which is an unpleasant sensation and negatively affects the living conditions of individuals, has important socioeconomic effects. Some researchers have made the definition of pain as an unpleasant sensory and emotional experience associated with potential tissue damage [(1).]

One of the main goals of the medical profession has been to reduce or eliminate the sensation of pain with treatment. Ache; Wherever in the body, it causes serious discomfort to the person. Toothache is the most common form of pain in the facial area [(2)]. However, the tolerance of the person to pain caused by inflammation in the teeth and surrounding tissues is very low.

Root canal treatment; It is applied to teeth whose pulp tissue is irreversibly damaged or whose pulp tissue will be exposed due to the planned restoration. Root canal treatment is a form of treatment that involves removing the tissue in question and filling the remaining space in a three-dimensional way by expanding, cleansing and filling the original form [(3)]. Filling the root canal, which is the last step of endodontic treatment, is of great importance for the long-term success of the treatment. The ideal root canal filling is achieved by sealing the root canal system starting from the dentin-cementum junction (from the physiological foramen apicale) to the coronal [(4)].

Postoperative pain is defined as pain of any degree that occurs after the primer root canal treatment, while acute flare-up pain is defined as pain after endodontic treatment at the onset or continuation of pain [(5)].

PAIN

The International Association for the Study of Pain (IASP) has described pain as a sensory, emotional feeling related to the past experiences of a person starting from any part of the body [(6)].

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The most important problem in studies on the subject is the assessment of pain. Various scales are used to assess pain:

a) **Visual Analogue Scale-VAS:** On the visual analog scale, which is a 10 cm scale, there are 10 values that start with "no pain" and end with "severe pain". It is used to measure and follow the severity of pain.
b) **Verbal Rating Scale-VRS:** In this evaluation, the patient chooses the appropriate one among the expressions of "no pain", "mild pain", "moderate pain" and "severe pain".
c) **Numerical Rating Scale-NRS**: The scale starts with the absence of pain (0) and is evaluated at the level of unbearable pain (10 or 100).
d) **Face Scale-FS:** The closest image to the patient's facial expression is determined.

CONCLUSION

Pain after canal treatment typically ranges from mild to moderate and can happen even after optimally performed root canal treatments. Recent developments in endodontics have reduced the incidence of pain after root canal treatment and improved patient satisfaction regarding postoperative pain. The effective management of postoperative pain is often considered an indicator of clinical excellence. However, further research is required to understand the physiology of pain and the mechanisms of relief associated with drugs and therapy.

REFERENCES

1. Loeser JD, Treede R-D. The Kyoto protocol of IASP basic pain Terminology*. Pain. 2008;137(3):473–7.
2. Lipton J, Ship J, Larach-Robinson D. Estimated prevalence and distribution of reported orofacial pain in the United States. J Am Dent Assoc. 1993;124(10):115–21.
3. Ercan E, Dalli M, Dülgergil ÇT. In vitro assessment of the effectiveness of chlorhexidine gel and calcium hydroxide paste with chlorhexidine against Enterococcus faecalis and Candida albicans. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2006;102(2):e27–31.
4. Önay EO, Ünver S, Üngör M. İki farklı taşkın kök kanal dolgu patındaki boyutsal değişimin ve periapikal iyileşme üzerindeki etkilerinin radyografik olarak incelenmesi. Gazi Üniversitesi Diş Hekim Fakültesi Derg. 2010;27(3):157–65.
5. ElMubarak AHH, Abu-bakr NH, Ibrahim YE. Postoperative pain in multiple-visit and single-visit root canal treatment. J Endod. 2010;36(1):36–9.
6. Aydın ON. Ağrı ve ağrı mekanizmalarına güncel bakış. 2002;
7. Iranmanesh F, Parirokh M, Haghdoost AA, Abbott P V. Effect of corticosteroids on pain relief following root canal treatment: A systematic review. Iran Endod J. 2017;12(2):123.
8. Trowbridge HO, Franks M, Korostoff E, Emling R. Sensory response to thermal stimulation in human teeth. J Endod. 1980;6(1):405–12.
9. Levin LG, Law AS, Holland GR, Abbott P V, Roda RS. Identify and define all diagnostic terms for pulpal health and disease states. J Endod. 2009;35(12):1645–57.
10. Närhi M. The neurophysiology of the teeth. Dent Clin North Am. 1990;34(3):439–48.

11. Reeh ES, ElDeeb ME. Referred pain of muscular origin resembling endodontic involvement: Case report. Oral surgery, oral Med oral Pathol. 1991;71(2):223–7.
12. Long A, Loescher AR, Robinson PP. A quantitative study on the myelinated fiber innervation of the periodontal ligament of cat canine teeth. J Dent Res. 1995;74(6):1310–7.
13. AYDIN ON. Ağrı ve ağrı mekanizmalarına güncel bakış. ADÜ Tıp Fakültesi Derg. 2002;3(2):37–48.
14. Brown AC, Beeler WJ, Kloka AC, Fields RW. Spatial summation of pre-pain and pain in human teeth. Pain. 1985;21(1):1–16.
15. Närhi MVO. The characteristics of intradental sensory units and their responses to stimulation. J Dent Res. 1985;64(4):564–71.
16. Markowitz K, Kim S. Hypersensitive teeth. Experimental studies of dentinal desensitizing agents. Dent Clin North Am. 1990;34(3):491–501.
17. Oloart L. Excitation of intradental sensory units by pharmacological agents. Acta Physiol Scand. 1974;92(1):48–55.
18. Byers MR. Dynamic plasticity of dental sensory nerve structure and cytochemistry. Arch Oral Biol. 1994;39:S13–21.
19. Harris R, Griffin CJ. Fine structure of nerve endings in the human dental pulp. Arch Oral Biol. 1968;13(7):773-IN30.
20. Hermanstyne TO, Markowitz K, Fan L, Gold MS. Mechanotransducers in rat pulpal afferents. J Dent Res. 2008;87(9):834–8.
21. Naseri M, Khayat A, Zamaheni S, Shojaeian S. Correlation between histological status of the pulp and its response to sensibility tests. Iran Endod J. 2017;12(1):20.
22. Abd-Elmeguid A, Donald CY, Kline LW, Moqbel R, Vliagoftis H. Dentin matrix protein-1 activates dental pulp fibroblasts. J Endod. 2012;38(1):75–80.
23. Henrici AT, Hartzell TB. The Bacteriology of Vital Pulps. J Natl Dent Assoc. 1920;7(4):375–7.
24. Rees JS, Addy M. A cross-sectional study of dentine hypersensitivity. J Clin Periodontol. 2002;29(11):997–1003.
25. Hargreaves KM. Cohen's pathways of the pulp tenth edition. Mosby Elsevier St Louis, Mo, USA. 2011;
26. Bender IB. Pulpal pain diagnosis—a review. J Endod. 2000;26(3):175–9.
27. Menakaya IN, Oderinu OH, Adegbulugbe IC, Shaba OP. Incidence of postoperative pain after use of calcium hydroxide mixed with normal saline or 0.2% chlorhexidine digluconate as intracanal medicament in the treatment of apical periodontitis. Saudi Dent J. 2015;27(4):187–93.
28. Melis M, Lobo SL, Ceneviz C, Zawawi K, Al-Badawi E, Maloney G, et al. Atypical odontalgia: a review of the literature. Headache J head face pain. 2003;43(10):1060–74.
29. Padilla M, Clark GT, Merrill RL. Topical medications for orofacial neuropathic pain: a review. J Am Dent Assoc. 2000;131(2):184–95.
30. O'Keefe EM. Pain in endodontic therapy: preliminary study. J Endod. 1976;2(10):315–9.
31. Ertan T, Şahinkesen G, Tunca YM. Evaluation of postoperative pain in root canal treatment. Agri [Internet]. 2010;22(4):159–64. Available from: https://dx.doi.org/
32. Yoldas O, Topuz A, Isçi AS, Oztunc H. Postoperative pain after endodontic retreatment: single-versus two-visit treatment. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2004;98(4):483–7.
33. Nekoofar MH, Sheykhrezae MS, Meraji N, Jamee A, Shirvani A, Jamee J, et al. Comparison of the effect of root canal preparation by using WaveOne and ProTaper on postoperative pain: a randomized clinical trial. J Endod. 2015;41(5):575–8.
34. ALAÇAM T, GÖRGÜL G, DARENDELİLER S, Oya B. Endodontik Tedavi Sonrası Ağrı Kontrolünde Naproksen Sodyumun Kullanılması. Gazi Üniversitesi Diş Hekim Fakültesi Derg. 1991;8(2):1–19.
35. Siqueira Jr JF, Rôças IN, Favieri A, Machado AG, Gahyva SM, Oliveira JCM, et al. Incidence of postoperative pain after intracanal procedures based on an antimicrobial strategy. J Endod. 2002;28(6):457–60.

36. Petrović V, Opačić-Galić V, Živković S. Postoperative pain after primary endodontic treatment and retreatment of asymptomatic teeth. Stomatol Glas Srb. 2011;58(2):75–81.
37. Siqueira Jr JF. Microbial causes of endodontic flare-ups. Int Endod J. 2003;36(7):453–63.
38. Kashefinejad M, Harandi A, Eram S, Bijani A. Comparison of single visit post endodontic pain using Mtwo rotary and hand K-file instruments: a randomized clinical trial. J Dent (Tehran). 2016;13(1):10.
39. Imura N, Zuolo ML. Factors associated with endodontic flare-ups: a prospective study. Int Endod J. 1995;28(5):261–5.
40. Comparin D, Moreira EJL, Souza EM, De-Deus G, Arias A, Silva EJNL. Postoperative pain after endodontic retreatment using rotary or reciprocating instruments: a randomized clinical trial. J Endod. 2017;43(7):1084–8.
41. Qian W, Ma T, Ye M, Li Z, Liu Y, Hao P. Microbiota in the apical root canal system of tooth with apical periodontitis. BMC Genomics. 2019;20(2):175–85.
42. Siqueira Jr JF, Barnett F. Interappointment pain: mechanisms, diagnosis, and treatment. Endod Top. 2004;7(1):93–109.
43. Hulsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endod Top. 2005;10(1):30–76.
44. Li Q, Zhang Q, Zou X, Yue L. Evaluation of four final irrigation protocols for cleaning root canal walls. Int J Oral Sci. 2020 Oct;12(1):29.
45. Sistemi S. DURUMUN DE Ğ ERLEND İ R İ LMES İ THE EVALUATION OF PERIAPICAL STATUS AND QUALITY OF ENDODONTIC TREATMENT ON A GROUP OF PATIENTS EXPERIENCED ENDODONTIC TREATMENT Ar ş . Gör . Dr . İ lkay PEKER *. 2009;1–7.
46. Ørstavik D, Mjör IA. Histopathology and x-ray microanalysis of the subcutaneous tissue response to endodontic sealers. J Endod. 1988;14(1):13–23.
47. Arias A, de la Macorra JC, Hidalgo JJ, Azabal M. Predictive models of pain following root canal treatment: a prospective clinical study. Int Endod J. 2013;46(8):784–93.
48. Yesilsoy C, Koren LZ, Morse DR, Rankow H, Bolanos OR, Furst ML. Post-endodontic obturation pain: a comparative evaluation. Quintessence Int (Berlin, Ger 1985). 1988;19(6):431–8.

Chapter 9

TECHNICAL LIMITATIONS AND PRACTICAL ISSUES IN THE USE OF CONE BEAM COMPUTED TOMOGRAPHY IN ORAL AND MAXILLOFACIAL SURGERY

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INTRODUCTION

The maxillofacial region contains complex anatomical structures in close proximity that represent different characteristics. The X-ray-based imaging techniques are used to evaluate the pathologies, to plan surgical interventions and to follow-up their results. The role of imaging modalities in the clinical practice of oral and maxillofacial (OMF) surgery, as well as in general dentistry, differs significantly from that in the medical specialties. The dynamic characteristics of the oral hard and soft tissues and the presence of various structures that may be affected by the pathological conditions makes it nearly impossible to perform surgical procedures only through reports written by radiologists as most medical specialties do. OMF surgeons often have to interpret the radiological images independently. For more than a century, the need for imaging in dentistry was mainly met with two-dimensional (2D) techniques. Although the computed tomography systems have been available in the field of medicine since 1970s, the access of dental professionals to this technology was limited. First introduced in the early 2000s, the cone-beam computed tomography (CBCT) device that allows the examination of anatomical structures from various planar orientations, provided a viable solution to the need of three-dimensional (3D) diagnostic information. However, the rapid transition from 2D systems to the examination of tomographic data has also brought some problems and challenges. The purpose of this article is to examine the technical limitations of the CBCT devices and their effects on the daily practice of OMF surgery.

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even being asked to waive their right to sue the lack of formal radiology report. The legal validity of such documents is questionable at best when a problem arises [53-55].

CONCLUSION

CBCT has become an indispensable part of the surgery practice. OMF surgeons therefore have to assume a new set of duties and responsibilities. They need to constantly develop their basic knowledge, increase their experience and recognize the technological infrastructure of the CBCT imaging systems in order to effectively use all the features of this device.

REFERENCES

1. Scarfe WC, Li Z, Aboelmaaty W, Scott SA, Farman AG. Maxillofacial cone beam computed tomography: essence, elements and steps to interpretation. *Aust Dent J, 2012*; *57 Suppl 1*, 46-60. Doi: 10.1111/j.1834-7819.2011.01657.x
2. Miracle AC, Mukherji SK. Conebeam CT of the head and neck, part 2: clinical applications. *AJNR Am J Neuroradiol, 2009*; *30* (7), 1285-1292. Doi: 10.3174/ajnr.A1654
3. Farman AG, Scarfe WC. Historical Perspectives on CBCT. In: Scarfe WC, Angelopoulos C, editors. *Maxillofacial Cone Beam Computed Tomography: Principles, Techniques and Clinical Applications*. Cham: Springer International Publishing; 2018. p. 3-11.
4. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. *J Can Dent Assoc, 2006*; *72* (1), 75-80.
5. Miracle AC, Mukherji SK. Conebeam CT of the head and neck, part 1: physical principles. *AJNR Am J Neuroradiol, 2009*; *30* (6), 1088-1095. Doi: 10.3174/ajnr.A1653
6. Scarfe WC, Farman AG. What is cone-beam CT and how does it work? *Dent Clin North Am, 2008*; *52* (4), 707-730, v. Doi: 10.1016/j.cden.2008.05.005
7. Weiss R, 2nd, Read-Fuller A. Cone Beam Computed Tomography in Oral and Maxillofacial Surgery: An Evidence-Based Review. *Dent J (Basel), 2019*; *7* (2). Doi: 10.3390/dj7020052
8. Ahmad M, Jenny J, Downie M. Application of cone beam computed tomography in oral and maxillofacial surgery. *Aust Dent J, 2012*; *57 Suppl 1*, 82-94. Doi: 10.1111/j.1834-7819.2011.01661.x
9. Ogawa M, Katagiri S, Koyanagi T, et al. Accuracy of cone beam computed tomography in evaluation of palatal mucosa thickness. *J Clin Periodontol, 2020*; *47* (4), 479-488. Doi: 10.1111/jcpe.13254
10. Lee WJ, Wilkinson CM, Hwang HS. An accuracy assessment of forensic computerized facial reconstruction employing cone-beam computed tomography from live subjects. *J Forensic Sci, 2012*; *57* (2), 318-327. Doi: 10.1111/j.1556-4029.2011.01971.x
11. Fourie Z, Damstra J, Gerrits PO, Ren Y. Accuracy and reliability of facial soft tissue depth measurements using cone beam computer tomography. *Forensic Sci Int, 2010*; *199* (1-3), 9-14. Doi: 10.1016/j.forsciint.2010.02.018
12. Siqueira de Lima L, Brunetto DP, da Cunha Goncalves Nojima M. Evaluation of facial soft

tissue thickness in symmetric and asymmetric subjects with the use of cone-beam computed tomography. *Am J Orthod Dentofacial Orthop, 2019*; *155* (2), 216-223. Doi: 10.1016/j.ajodo.2018.03.024

13. Amine K, Slaoui S, Kanice FZ, Kissa J. Evaluation of maxillary sinus anatomical variations and lesions: A retrospective analysis using cone beam computed tomography. *J Stomatol Oral Maxillofac Surg, 2020*; *121* (5), 484-489. Doi: 10.1016/j.jormas.2019.12.021
14. Missias EM, Nascimento E, Pontual M, et al. Prevalence of soft tissue calcifications in the maxillofacial region detected by cone beam CT. *Oral Dis, 2018*; *24* (4), 628-637. Doi: 10.1111/odi.12815
15. Xu J, Sisniega A, Zbijewski W, et al. Technical assessment of a prototype cone-beam CT system for imaging of acute intracranial hemorrhage. *Med Phys, 2016*; *43* (10), 5745. Doi: 10.1118/1.4963220
16. Drage NA, Sivarajasingam V. The use of cone beam computed tomography in the management of isolated orbital floor fractures. *Br J Oral Maxillofac Surg, 2009*; *47* (1), 65-66. Doi: 10.1016/j.bjoms.2008.05.005
17. Schweitzer AD, Niogi SN, Whitlow CT, Tsiouris AJ. Traumatic Brain Injury: Imaging Patterns and Complications. *Radiographics, 2019*; *39* (6), 1571-1595. Doi: 10.1148/rg.2019190076
18. Shintaku WH, Venturin JS, Azevedo B, Noujeim M. Applications of cone-beam computed tomography in fractures of the maxillofacial complex. *Dent Traumatol, 2009*; *25* (4), 358-366. Doi: 10.1111/j.1600-9657.2009.00795.x
19. Mao W, Gardner SJ, Snyder KC, et al. On the improvement of CBCT image quality for soft tissue-based SRS localization. *J Appl Clin Med Phys, 2018*; *19* (6), 177-184. Doi: 10.1002/acm2.12470
20. Wu P, Sisniega A, Stayman JW, et al. Cone-beam CT for imaging of the head/brain: Development and assessment of scanner prototype and reconstruction algorithms. *Med Phys, 2020*; *47* (6), 2392-2407. Doi: 10.1002/mp.14124
21. Makins SR. Artifacts interfering with interpretation of cone beam computed tomography images. *Dent Clin North Am, 2014*; *58* (3), 485-495. Doi: 10.1016/j.cden.2014.04.007
22. Schulze RK, Berndt D, d'Hoedt B. On cone-beam computed tomography artifacts induced by titanium implants. *Clin Oral Implants Res, 2010*; *21* (1), 100-107. Doi: 10.1111/j.1600-0501.2009.01817.x
23. Fienitz T, Schwarz F, Ritter L, et al. Accuracy of cone beam computed tomography in assessing peri-implant bone defect regeneration: a histologically controlled study in dogs. *Clin Oral Implants Res, 2012*; *23* (7), 882-887. Doi: 10.1111/j.1600-0501.2011.02232.x
24. Vanderstuyft T, Tarce M, Sanaan B, et al. Inaccuracy of buccal bone thickness estimation on cone-beam CT due to implant blooming: An ex-vivo study. *J Clin Periodontol, 2019*; *46* (11), 1134-1143. Doi: 10.1111/jcpe.13183
25. Sirin Y, Yildirimturk S, Aytugar E, et al. A comparison of panoramic radiography and cone beam computed tomography in the detection of osteosynthesis complications in sheep mandibular angle fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol, 2019*; *127* (2), 167-174. Doi: 10.1016/j.oooo.2018.10.001
26. Sirin Y, Horasan S, Yaman D, et al. Detection of crestal radiolucencies around dental implants: an in vitro experimental study. *J Oral Maxillofac Surg, 2012*; *70* (7), 1540-1550. Doi: 10.1016/j.joms.2012.02.024
27. Bhoosreddy A, Sakhavalkar P. Image deteriorating factors in cone beam computed tomogra-

phy, their classification, and measures to reduce them: A pictorial essay. *Journal of Indian Academy of Oral Medicine and Radiology, 2014*; *26* (3), 293-297. Doi: 10.4103/0972-1363.145009

28. Nardi C, Borri C, Regini F, et al. Metal and motion artifacts by cone beam computed tomography (CBCT) in dental and maxillofacial study. *Radiol Med, 2015*; *120* (7), 618-626. Doi: 10.1007/s11547-015-0496-2
29. Spin-Neto R, Wenzel A. Patient movement and motion artefacts in cone beam computed tomography of the dentomaxillofacial region: a systematic literature review. *Oral Surg Oral Med Oral Pathol Oral Radiol, 2016*; *121* (4), 425-433. Doi: 10.1016/j.oooo.2015.11.019
30. Yildizer Keris E, Demirel O, Ozdede M. Evaluation of motion artifacts in cone-beam computed tomography with three different patient positioning. *Oral Radiol, 2021*; *37* (2), 276-281. Doi: 10.1007/s11282-020-00446-x
31. Schropp L, Stavropoulos A, Gotfredsen E, Wenzel A. Comparison of panoramic and conventional cross-sectional tomography for preoperative selection of implant size. *Clin Oral Implants Res, 2011*; *22* (4), 424-429. Doi: 10.1111/j.1600-0501.2010.02006.x
32. Wolff C, Mucke T, Wagenpfeil S, et al. Do CBCT scans alter surgical treatment plans? Comparison of preoperative surgical diagnosis using panoramic versus cone-beam CT images. *J Craniomaxillofac Surg, 2016*; *44* (10), 1700-1705. Doi: 10.1016/j.jcms.2016.07.025
33. Kammerer PW, Thiem D, Eisenbeiss C, et al. Surgical evaluation of panoramic radiography and cone beam computed tomography for therapy planning of bisphosphonate-related osteonecrosis of the jaws. *Oral Surg Oral Med Oral Pathol Oral Radiol, 2016*; *121* (4), 419-424. Doi: 10.1016/j.oooo.2015.11.012
34. Kaeppler G, Cornelius CP, Ehrenfeld M, Mast G. Diagnostic efficacy of cone-beam computed tomography for mandibular fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol, 2013*; *116* (1), 98-104. Doi: 10.1016/j.oooo.2013.04.004
35. Matzen LH, Christensen J, Hintze H, Schou S, Wenzel A. Influence of cone beam CT on treatment plan before surgical intervention of mandibular third molars and impact of radiographic factors on deciding on coronectomy vs surgical removal. *Dentomaxillofac Radiol, 2013*; *42* (1), 98870341. Doi: 10.1259/dmfr/98870341
36. Baqain ZH, AlHadidi A, AbuKaraky A, Khader Y. Does the Use of Cone-Beam Computed Tomography Before Mandibular Third Molar Surgery Impact Treatment Planning? *J Oral Maxillofac Surg, 2020*; *78* (7), 1071-1077. Doi: 10.1016/j.joms.2020.03.002
37. Hermann L, Wenzel A, Schropp L, Matzen LH. Impact of CBCT on treatment decision related to surgical removal of impacted maxillary third molars: does CBCT change the surgical approach? *Dentomaxillofac Radiol, 2019*; *48* (8), 20190209. Doi: 10.1259/dmfr.20190209
38. Fatima A, Mishra s. Knowledge and Attitude of Dentists and Dental Students Towards Cone-Beam Computed Tomography. *Journal of Research in Dental and Maxillofacial Sciences, 2020*; *5* (4), 26-30. Doi: 10.29252/jrdms.5.4.26
39. Al-Rawi WT, Jacobs R, Hassan BA, Sanderink G, Scarfe WC. Evaluation of web-based instruction for anatomical interpretation in maxillofacial cone beam computed tomography. *Dentomaxillofac Radiol, 2007*; *36* (8), 459-464. Doi: 10.1259/dmfr/25560514
40. Savoldi F, Yeung AWK, Tanaka R, et al. Dry Skulls and Cone Beam Computed Tomography (CBCT) for Teaching Orofacial Bone Anatomy to Undergraduate Dental Students. *Anat Sci*

Educ, 2021; *14* (1), 62-70. Doi: 10.1002/ase.1961

41. Kong N, Hui M, Miao F, et al. Mandibular incisive canal in Han Chinese using cone beam computed tomography. *Int J Oral Maxillofac Surg, 2016*; *45* (9), 1142-1146. Doi: 10.1016/j.ijom.2016.04.019
42. Serman NJ. The mandibular incisive foramen. *J Anat, 1989*; *167*, 195-198. Doi:
43. Pauwels R, Beinsberger J, Collaert B, et al. Effective dose range for dental cone beam computed tomography scanners. *Eur J Radiol, 2012*; *81* (2), 267-271. Doi: 10.1016/j.ejrad.2010.11.028
44. Wenzel A, Moystad A. Work flow with digital intraoral radiography: a systematic review. *Acta Odontol Scand, 2010*; *68* (2), 106-114. Doi: 10.3109/00016350903514426
45. Fryback DG, Thornbury JR. The efficacy of diagnostic imaging. *Med Decis Making, 1991*; *11* (2), 88-94. Doi: 10.1177/0272989X9101100203
46. Sirin Y, Yildirimturk S, Horasan S, Guven K. Direct Three-Dimensional Diagnosis of Ex Vivo Facial Fractures. *J Craniofac Surg, 2019*; *30* (5), e420-e424. Doi: 10.1097/SCS.0000000000005445
47. Caglayan F, Tozoglu U. Incidental findings in the maxillofacial region detected by cone beam CT. *Diagn Interv Radiol, 2012*; *18* (2), 159-163. Doi: 10.4261/1305-3825.DIR.4341-11.2
48. Fatahi N, Krupic F, Hellstrom M. Quality of radiologists' communication with other clinicians--As experienced by radiologists. *Patient Educ Couns, 2015*; *98* (6), 722-727. Doi: 10.1016/j.pec.2015.02.009
49. A GP. Quality of referral: What information should be included in a request for diagnostic imaging when a patient is referred to a clinical radiologist? *J Med Imaging Radiat Oncol, 2017*; *61* (3), 299-303. Doi: 10.1111/1754-9485.12577
50. Schreiber JJ, Anderson PA, Hsu WK. Use of computed tomography for assessing bone mineral density. *Neurosurg Focus, 2014*; *37* (1), E4. Doi: 10.3171/2014.5.FOCUS1483
51. Gonzalez-Garcia R, Monje F. The reliability of cone-beam computed tomography to assess bone density at dental implant recipient sites: a histomorphometric analysis by micro-CT. *Clin Oral Implants Res, 2013*; *24* (8), 871-879. Doi: 10.1111/j.1600-0501.2011.02390.x
52. Pauwels R, Jacobs R, Singer SR, Mupparapu M. CBCT-based bone quality assessment: are Hounsfield units applicable? *Dentomaxillofac Radiol, 2015*; *44* (1), 20140238. Doi: 10.1259/dmfr.20140238
53. Friedland B, Miles DA. Liabilities and risks of using cone beam computed tomography. *Dent Clin North Am, 2014*; *58* (3), 671-685. Doi: 10.1016/j.cden.2014.04.005
54. Friedland B. Conebeam computed tomography: legal considerations. *Alpha Omegan, 2010*; *103* (2), 57-61. Doi: 10.1016/j.aodf.2010.03.008
55. Friedland B, Scarfe WC. Ethical and Medicolegal Issues Related to CBCT. In: Scarfe WC, Angelopoulos C, editors. *Maxillofacial Cone Beam Computed Tomography: Principles, Techniques and Clinical Applications*. Cham: Springer International Publishing; 2018. p. 191-211.

Chapter 10

OCCLUSAL SPLINTS AS A TREATMENT MODALITY FOR NOCTURNAL BRUXISM IN ADULTS

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INTRODUCTION

Nocturnal bruxism is a repetitive rhythmic activation of masticatory muscles, characterised by clenching and/or grinding of the teeth during sleep. It is thought to be one of the most significant parafunctional activities of the stomatognathic system (1).

The incidence of nocturnal bruxism is conservatively estimated to be between 5% and 10% of the adult population (2).

Many patients clench or grind their teeth, are unaware of the activity when it occurs during sleep, because there is no discomfort or pain. Patients with disturbing symptoms such as jaw pain or stiffness, headache, difficult mouth opening, increased tooth sensitivity often consult with the clinician to diagnose problems and predict the use of an occlusal splint to be worn during sleep. Although the use of an occlusal splint is effective in preventing tooth wear during sleep, it does not eliminate unconscious clenching/grinding activity or the associated pain or discomfort. (5).

Bruxism may have effect on muscles: masticatory muscle tenderness (6), and masticatory muscle hypertrophy (6,7).

In cases of protrusive (forward and backward) bruxism associated with grinding or jaw sliding between centric and eccentric positions, the lateral pterygoid muscle suffers a contraction under muscular lengthening during the slow condylar retrusion into the joint cavity. The same happens with the elevator muscles during laterotrusive bruxism (from right to left) or protrusive under grinding or jaw sliding between centric and eccentric positions. During this eccentric muscular work, the muscle develops different magnitudes of muscular tension (depending on the load torque) as it becomes larger. This is the position in which there may be greater probability of muscular damage (8).

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guidance splints was significantly reduce elevator muscle activity during lateral movements than with the intermediate and posterior group function.

CONCLUSION

Moreover, other studies (28–30) reported a significant reduction in the muscle activity developed through tooth clenching during the maximum dental intercuspation when such activity was performed laterally over canine guidance.

However, Graham and Rugh (32) compared canine guidance splints with first molars disclusion splints in 10 subjects sample. In contrast to the finding of the above studies, both types of splint were found to reduce muscle activity in a similar way during lateral movements under tooth clenching in the lateral jaw position.

REFERENCES

1. Piquero K, Sakurai K. A clinical diagnosis of diurnal (non-sleep) bruxism in denture wearers. J Oral Rehabil. 2000;27:473–82.
2. Hicks RA, Chancellor C. Nocturnal bruxism and type A-B behavior in college students. Psychol Rep. 1987 Jun;60(3 Pt 2):1211–4.
3. Lavigne Gj, Manzini C. Bruxism. In: Meir H. Kryger, Thomas Roth, William C. Dement, editors. Principles and Practice of Sleep Medicine. 5th ed. W.B. Saunders Co., Philadelphia; 2011. p. 773–85.
4. Bader G, Lavigne and G. Sleep bruxism; an overview of an oromandibular sleep movement disorder. 2000;4(1):27–43.
5. Koyano K, Tsukiyama Y, Ichiki R. Local factors associated with parafunction and prosthodontics. Int J Prosthodont. 2005 Jan;18(4):293–4.
6. Dubé C, Rompré PH, Manzini C, Guitard F, de Grandmont P, Lavigne GJ. Quantitative polygraphic controlled study on efficacy and
7. Carra MC, Huynh N, Lavigne G. Sleep bruxism: a comprehensive overview for the dental clinician interested in sleep medicine. Dent Clin North Am. 2012 Apr;56(2):387–413.
8. Koyano K, Tsukiyama Y, Ichiki R, Kuwata T. Assessment of bruxism in the clinic. J Oral Rehabil. 2008 Jul;35(7):495–508.
9. Arturo E.Manns Freese. Effect of Bruxism on Muscle. In: Bruxism theory and practice. D. A. Paesani (ed). (2010).
10. Ekfeldt A. Incisal and occlusal tooth wear and wear of some prosthodontic materials. An epidemiological and clinical study. Swed Dent J Suppl. 1989;65:1–62.
11. McGuire MK, Nunn ME. Prognosis versus actual outcome. IV. The effectiveness of clinical parameters and IL-1 genotype in accurately predicting prognoses and tooth survival. J Periodontol. 1999;70(1):49–56.
12. Ratcliff S, Becker IM, Quinn L. Type and incidence of cracks in posterior teeth. J Prosthet Dent. 2001;86(2):168–72.
13. Ekfeldt A, Christiansson U, Eriksson T, Lindén U, Lundqvist S, Rundcrantz T, et al. A retrospective analysis of factors associated with multiple implant failures in maxillae. Clin Oral Implants Res. 2001;12(5):462–7.
14. Brägger U, Aeschlimann S, Bürgin W, Hämmerle CH, Lang NP. Biological and technical complications and failures with fixed partial dentures (FPD) on implants and teeth after four to five years of function. Clin Oral Implants Res. 2001;12(1):26–34.
15. Roark AL, Glaros AG, O'Mahony AM, Mahony AMO. Effects of interocclusal splints on EMG activity during parafunctional tooth contact. J Oral Rehabil. 2003;30:573–7.

16. Perel ML. Parafunctional habits, nightguards, and root form implants. Implant Dent. 1994;3(4):261–3.
17. Davis CR. Maintaining immediate posterior disclusion on an occlusal splint for patient with severe bruxism habit. J Prosthet Dent. 1996 Mar;75(3):338–9.
18. Nassif NJ, al-Ghamdi KS. Managing bruxism and temporomandibular disorders using a centric relation occlusal device. Compend Contin Educ Dent. 1999;20(11):1071–4,1076,1078 passim; quiz 1086.
19. Cowie RR. The clinical use of night guards: occlusal objectives. Dent Today. 2004 Sep;23(9):112, 114–5.
20. Grozev L, Michailov T. Treatment of bruxism and bruxomania (clinically tested). Folia Med (Plovdiv). 1999 Jan;41(1):147–8.
21. Anthony TH. Soft thermoplastics in bruxism appliances. Trends Tech Contemp Dent Lab. 1995 Sep;12(7):32–6.
22. Okeson JP. The effects of hard and soft occlusal splints on nocturnal bruxism. J Am Dent Assoc. 1987;114(6):788–91.
23. Peter E. Dawson. Evaluation, Diagnosis, And Treatment Of Occlusal Problems. Louis;Mosby; 1989. 186 p.
24. Ré J-P, Perez C, Darmouni L, Carlier JF, Orthlieb J-D. The occlusal splint therapy. Int J Stomatol Occlusion Med. 2009 Jul 21;2(2):82–6.
25. Okeson, Jeffrey P.D. Management of Temporomandibular Disorders and Occlusion. 4th ed. Orlando, Florida, U.S.A.: Mosby; 1997.
26. Manns A, Miralles R, Valdivia J, Bull R. Influence of variation in anteroposterior occlusal contacts on electromyographic activity. J Prosthet Dent. 1989;61(5):617–23.
27. Shupe RJ, Mohamed SE, Christensen L V, Finger IM, Weinberg R. Effects of occlusal guidance on jaw muscle activity. J Prosthet Dent. 1984 Jun;51(6):811–8.
28. D'Amico A. The canine teeth: Normal functional relation of the natural teeth of man. Calif Dent Assoc. 1958;26:194–208.
29. Lous I. Treatment of TMJ syndrome by pivots. J Prosthet Dent. 1978 Aug;40(2):179-82.
30. Fitins D, Sheikholeslam A. Effect of canine guidance of maxillary occlusal splint on level of activation of masticatory muscles. Swed Dent J. 1993;17(6):235–41.
31. Baad-Hansen L, Jadidi F, Castrillon E, Thomsen PB, Svensson P. Effect of a nociceptive trigeminal inhibitory splint on electromyographic activity in jaw closing muscles during sleep. J Oral Rehabil. 2007;34(2):105–11.
32. Williamson EH, Lundquist DO. Anterior guidance: its effect on electromyographic activity of the temporal and masseter muscles. J Prosthet Dent. 1983 Jun;49(6):816–23.
33. Graham GS, Rugh JD. Maxillary splint occlusal guidance patterns and electromyographic activity of the jaw-closing muscles. J Prosthet Dent. 1988 Jan;59(1):73–7.
34. Rugh JD, Graham GS, Smith JC, Ohrbach RK. Effects of canine versus molar occlusal splint guidance on nocturnal bruxism and craniomandibular symptomatology. J Craniomandib Disord. 1989 Jan;3(4):203–10.

Chapter 11

THE ROLE OF DENTAL RADIOGRAPHY IN FORENSIC ODONTOLOGY

Dilara Nil GUNACAR[1]

INTRODUCTION

Forensic dentistry (forensic odontology) is an important part of forensic sciences and it is a branch of dentistry that helps justice in forensic cases in terms of evaluation of dental evidence based on dental findings of individuals, determination of identity, age and gender status, and legal responsibilities of dentists.[1] The main fields of study belonging to this science are identification or age and gender determination through the diagnostic and therapeutic examination and evaluation of injuries related to jaw, teeth and oral soft tissues, especially the determination of damage to individuals in criminal investigations and / or collective disasters and detection, examination and evaluation of bite marks that are common in sexual assault, child abuse and personal defense situations.[1,2] Today, in case of mass disasters such as migration waves, airplane crashes, fires, earthquakes and floods, or the absence of healthy birth and population records in our country, especially in rural areas, identifying individuals is extremely important. Especially in forensic medicine practices, dentists also have important responsibilities in cases such as criminal liability, legal competence, the ability to perceive the legal meaning and consequences of the act and to direct their behavior, recruitment, employment, marriage, retirement.[3] For this purpose, odontological determination is attempted by using ante-mortem (pre-death) and post-mortem (post-death) records. Identification based on radiographs was first used in 1921 by Schuller, who showed that the frontal sinuses are individual.[4] Jaws and teeth can be used as a reliable method of dental identification due to their resistance to burning, physical, chemical and mechanical effects. Also, since dental treatments have differences between individuals, this makes it possible to identify even through routine dental radiographs.[5]

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the help of these radiographs, it has been stated that age determination can be made with many studies based on the visibility of the root pulp due to secondary dentin production[30], the visibility of the periodontal ligament space surrounding the root[31], pulp area, and tooth area measurements[32].

CONE-BEAM COMPUTED TOMOGRAPHY

Cone-beam computed tomography (dental volumetric tomography) is an imaging method by which a three-dimensional image of the area to be imaged in the maxillofacial region is obtained without superposition and with a lower cost and lower radiation compared to computed tomography.[12] Forensic age determination can be preferred as an imaging method in trauma cases, facial evaluations, evaluation of foreign body localization such as bullet, fracture detection, and evaluation of the location of fixation plates.[4] There are age determination methods based on 3D evaluations where pulp volume, crown pulp volume, and tooth volume are calculated and proportioned[33,34], and by measuring bucco-lingual and mesio-distal dimensions of teeth[35]. In addition, there are studies conducted on this imaging method that show that sex determination can be made based on mandibular morphometric measurements (ramus width, gonial angle, bicondylar width, etc.).[36]

CONCLUSION

As a result, dental radiographs, which have an extremely important place in dentistry, are among the most important auxiliary elements in the identification of individuals in the science of forensic dentistry. The use of dental radiographs in forensic odontology is widespread thanks to its advantages such as being a non-invasive method and providing identification with inexpensive and objective findings. Therefore, dental radiographs obtained from patients should be properly archived and interpreted correctly by dentists.

REFERENCES

1. Harorlı, A. (2006). *Adli Diş Hekimliği (1. Baskı)*, Erzurum: Atatürk Üniversitesi Yayınları
2. Afşin, H. & Karadayı, B. Felaket Kurbanlarının Kimliklendirilmesinde Diş Kayıtlarının Önemi. *The Bulletin of Legal Medicine*, *2012*; *17* (2), 31-37.
3. Koç, S. & Can, M. (2009*). Birinci Basamakta Adli Tıp (1.Baskı).* İstanbul: Türk Tabipler Birliği
4. Canger, E.M. & Arslan, D.S. Adli Diş Hekimliğinde Radyolojinin Kullanımı. *Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi*, *2013; 23* (2), 252-60.
5. Queiroz Abreu, T., Figueiredo de Oliveira, A.E., Bernardes Ferreira, E., *et al*. Radiographic analysis of forensic dentistry. *Revista Odonto Ciencia*, *2016; 4* (3), 101-10.
6. Wood, R.E. Forensic aspects of maxillofacial radiology. *Forensic science international*, 2006; *159*, 47-55.
7. Akay, G., Atak, N., & Güngör, K. Adli dişhekimliğinde dişler kullanılarak yapılan yaş tayini yöntemleri. *Ege Üniversitesi Dişhekimliği Fakültesi Dergisi*, *2018; 39* (2), 73-82.

8. Acharya, A.B., & Mainali, S. Sex discrimination potential of buccolingual and mesiodistal tooth dimensions. *Journal of forensic sciences*, *2008; 53* (4), 790-2.
9. Maloth, K.N., Kundoor, V.K.R., Vishnumolakala, S.S.L.P., *et al.* Mandibular ramus: A predictor for sex determination-A digital radiographic study. *Journal of Indian Academy of Oral Medicine and Radiology*, *2017; 29* (3), 242.
10. Alves, M.C., & Haiter-Neto, F. Mandibular sexual dimorphism analysis in CBCT scans. *Journal of Forensic and Legal Medicine*, *2015; 38*, 106-10.
11. Joseph, A.P., Harish, R.K., Mohammed, P.K.R., *et al.* How reliable is sex differentiation from teeth measurements. *Oral Maxillofac Pathol J*, *2013; 4* (1), 289-92.
12. Harorlı, A. (2014) *Ağız, Diş ve Çene Radyolojisi (1. Baskı)* İstanbul; Nobel Tıp Kitapevleri
13. Paramkusam, G., Nadendla, L.K., Devulapalli, R.V., et al. Morphometric analysis of canine in gender determination: Revisited in India. *Indian Journal of Dental Research*, *2014; 25* (4), 425.
14. Pratapiene, M., Cicciu, M., & Juodzbalys, G. Canines mesiodistal measures as the key to sex prediction: a systematic review and meta-analysis. *Minerva pediatrica*, *2015; 68* (4), 288-98.
15. Valenzuela, A., Martin-de las Heras, S., Marques, T., *et al.* The application of dental methods of identification to human burn victims in a mass disaster. *Int J Legal Med, 2000; 113*, 236-9.
16. Kvaal, S.I., Kolltveit, K.M., Thomsen, I.O., *et al.* Age estimation of adults from dental radiographs. *Forensic science international*, *1995; 74* (3), 175-85.
17. MacLean, D.F., Kogon, S.L., Stitt, L.W. Validation of dental radiographs for human identification. *J Forensic Science*, *1994; 39*, 1195-200.
18. Kogon, S.L., McKay, A.E., MacLean, D.F. The validity of bitewing radiographs for the dental identification of children. *J Forensic Science, 1995; 40,* 1055-7.
19. Forrest, A.S. Collection and recording of radiological information for forensic purposes. *Aust Dent J*, *2012; 57*, 24-32.
20. Paknahad, M., Vossoughi, M., & Zeydabadi, F.A. A radio-odontometric analysis of sexual dimorphism in deciduous dentition. *Journal of forensic and legal medicine*, *2016; 44*, 54-7.
21. Hassel, B., Farman, A.G. Skeletal maturation evulation using cervical vertebrae. *Am J Orthod Dentofacial Orthop, 1995; 107* (1), 58-66.
22. Sidhu, R., Chandra, S., Devi, P., *et al.* Forensic importance of maxillary sinus in gender determination: a morphometric analysis from Western Uttar Pradesh, India. *European Journal of General Dentistry*, *2014; 3* (1), 53.
23. Khaitan, T., Kabiraj, A., Ginjupally, U., *et al.* Cephalometric analysis for gender determination using maxillary sinus index: a novel dimension in personal identification. *International journal of dentistry*, *2017;* (2017), 1-5.
24. Baransel Isır, A., Dülger, H.E. 1998-2005 yılları arasında Gaziantep Üniversitesi Adli Tıp Anabilim Dalında raporlandırılan yaş tayini olgularının irdelenmesi. *Türkiye Klinikleri Adli Tıp Dergisi, 2007; 4* (1), 1-6.
25. Greulich, W.W., Pyle, S.I. (1959) *Radiographic atlas of skeletal development of the hand and wrist. (2nd ed.)* California: University Pres
26. White S.C., Pharoah M.J. (2014) *Oral Radiology: Principles and Interpretation. (7th ed)* St. Louis: Mosby, Elsevier Science
27. Lee, S.S., Choi, J.H., Yoon, C.L., *et al.* The diversity of dental patterns in the orthopantomography and its significance in human identification. *J Forensic Sci, 2004; 49*, 784-6.
28. Sairam, V., Geethamalika, M.V., Kumar, P.B., *et al.* Determination of sexual dimorphism in humans by measurements of mandible on digital panoramic radiograph. *Contemporary clinical dentistry*, *2016; 7* (4), 434.
29. Capitaneanu, C., Willems, G., Jacobs, R., *et al.* Sex estimation based on tooth measurements using panoramic radiographs. *International journal of legal medicine*, *2017; 131* (3), 813-21.
30. Olze, A., Solheim, T., Schulz, R., *et al.* Evaluation of the radiographic visibility of the root pulp in the lower third molars for the purpose of forensic age estimation in living individuals. *International journal of legal medicine*, *2010; 124* (3), 183-6.
31. Olze, A., Solheim, T., Schulz, R., *et al.* Assessment of the radiographic visibility of the perio-

dontal ligament in the lower third molars for the purpose of forensic age estimation in living individuals. *International journal of legal medicine*, *2010; 124* (5), 445-8.
32. Cameriere, R., De Luca, S., Alemán, I., *et al.* Age estimation by pulp/tooth ratio in lower premolars by orthopantomography. *Forensic science international*, *2012; 214* (1-3), 105-12.
33. Ge, Z.P., Ma, R.H., Li, G., *et al.* Age estimation based on pulp chamber volume of first molars from cone-beam computed tomography images. *Forensic science international*, *2015; 253*, 133-e1.
34. Ge, Z.P., Yang, P., Li, G., *et al.* Age estimation based on pulp cavity/chamber volume of 13 types of tooth from cone beam computed tomography images. *International journal of legal medicine*, *2016; 130* (4), 1159-67.
35. Yang, F., Jacobs, R., & Willems, G. Dental age estimation through volume matching of teeth imaged by cone-beam CT. *Forensic science international*, *2006; 159*, 78-83.
36. Kharoshah, M.A.A., Almadani, O., Ghaleb, S.S., *et al.* Sexual dimorphism of the mandible in a modern Egyptian population. *Journal of forensic and legal medicine*, *2010; 17* (4), 213-5.

Chapter 12

SPORTS DENTISTRY

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INTRODUCTION

In recent years, there has been increasing the importance of sports in the world and in our country, the number of individuals who engage in sports activities and participate in sports competitions is also increasing. Dental traumas frequently occur among the injuries that can occur as a result of falling or collisions during sports activities (1). Soft tissue injuries or dentoalveolar injuries can be seen indirectly or as a result of direct blows on the teeth (2, 3).

Sports accidents are considered one of the most common causes of maxillofacial injuries. Studies have shown that approximately 30% of trauma-related cases in children and adults are sports-related (1). In the maxillofacial region, serious traumas related to neurosurgery or plastic surgery may occur, as well as dentoalveolar traumas that require maxillofacial surgery, endodontic treatment, restorative treatments. These injuries, which are frequently seen in childhood and adolescence; by causing periodontium injuries, dental hard tissue injuries, luxation injuries or avulsion. It causes aesthetic and functional problems as well as negatively affecting individuals psychosocially (4).

The International Academy of Sports Dentistry emerged in 1983 and raised awareness about the prevention of sports-related orofacial trauma. Sports Dentistry and Dental Traumatology Congress convened for the first time in 2001 and after this congress, "International Association of Dental Traumatology (IADT)" and "International Academy of Sports Dentistry (IASD)", there was cooperation between them. Previously known as "Endodontics and Dental Traumatology", the name of the journal has been changed and renamed to "Dental Traumatology" and has been qualified as the official publication of both IADT and IASD (5). The scope of the duty of Sports Dentistry, according to IASD; includes the prevention and treatment of sports-related orofacial injuries, as well as raising awareness by collecting and publishing data about these injuries (5, 6).

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CONCLUSION

Today, with the increasing interest in sports activities and the importance given to professionalism in almost every field, 'Sports Dentistry' is emerging as a fairly new field in the world. Maxillofacial or dental injuries can be seen frequently among sports injuries. Prevention of possible traumas which can occur in the future is quite important as the management and treatment of the trauma process. Because of this reason; it is thought that as a result of raising awareness by informing the parents and trainers of individuals who are interested in sports activities, it will contribute to the oral and dental health of the athletes.

REFERENCES

1. Gassner R, Tuli T, Hächl O, et al. Cranio-maxillofacial trauma: a 10 year review of 9543 cases with 21 067 injuries. Journal of cranio-maxillofacial surgery. 2003;31(1):51-61.
2. Gassner R, Tuli T, Hächl O, et al. Craniomaxillofacial trauma in children: a review of 3,385 cases with 6,060 injuries in 10 years. Journal of oral and maxillofacial surgery. 2004;62(4):399-407.
3. Singh G, Garg S, Damle SG, et al. A study of sports related occurrence of traumatic orodental injuries and associated risk factors in high school students in north India. Asian journal of sports medicine. 2014;5(3).
4. Tsuchiya S, Tsuchiya M, Momma H, et al. Factors associated with sports-related dental injuries among young athletes: a cross-sectional study in Miyagi prefecture. BMC oral health. 2017;17(1):168.
5. Ranalli DN. Sports dentistry and dental traumatology. Dental Traumatology. 2002;18(5):231-236.
6. Bayraklı M, BOZKURT OD, KASIMOĞLU Y, et al. DİŞ HEKİMLERİNİN SPOR DİŞ HEKİMLİĞİNDE TRAVMA VE. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2018:1-1.
7. Organization WH. International statistical classification of diseases and related health problems: instruction manual: World Health Organization; 2004.
8. Pinkham J, Kohn D. Epidemiology and prediction of sports-related traumatic injuries. Dental clinics of North America. 1991;35(4):609-626.
9. Andreasen JO, Bakland LK, Flores MT, et al. Traumatic dental injuries: a manual: John Wiley & Sons; 2011.
10. Arnheim D. Essentials of Athletic Training. St. Louis, MO: Times Mirror. Mosby College Publishing; 1987.
11. Kalyon PDTA. Spor Hekimliği Sporcu sağlığı ve Spor Sakatlıkları. Ankara: Gata Basımevi1995. 1-284 p.
12. Frontera RR, Zanin L, Ambrosano GMB, et al. Orofacial trauma in Brazilian basketball players and level of information concerning trauma and mouthguards. Dental traumatology. 2011;27(3):208-216.
13. Control CfD, Prevention. Nonfatal sports-and recreation-related injuries treated in emergency departments--United States, July 2000-June 2001. MMWR: Morbidity and mortality weekly report. 2002;51(33):736-740.
14. Uslu B. Sporcularda Baş, Boyun ve Bel Sakatlıkları. Türkiye Klinikleri Dahili Tıp Bilimleri Dergisi. 2006;2(27):41-45.
15. Barth JT, Freeman JR, Broshek DK, et al. Acceleration-deceleration sport-related concussion: the gravity of it all. Journal of athletic training. 2001;36(3):253.
16. Wennberg R, Tator C. National Hockey League reported concussions, 1986-87 to 2001-02. Canadian Journal of Neurological Sciences. 2003;30(3):206-209.

17. Lieger O, Von Arx T. Orofacial/cerebral injuries and the use of mouthguards by professional athletes in Switzerland. Dental traumatology. 2006;22(1):1-6.
18. Von Arx T, Flury R, Tschan J, et al. Exercise capacity in athletes with mouthguards. International journal of sports medicine. 2008;29(05):435-438.
19. Sorli JM. Equestrian injuries: a five year review of hospital admissions in British Columbia, Canada. Injury Prevention. 2000;6(1):59-61.
20. Thomas KE, Annest JL, Gilchrist J, et al. Non-fatal horse related injuries treated in emergency departments in the United States, 2001–2003. British journal of sports medicine. 2006;40(7):619-626.
21. Ueeck BA, Dierks EJ, Homer LD, et al. Patterns of maxillofacial injuries related to interaction with horses. Journal of oral and maxillofacial surgery. 2004;62(6):693-696.
22. Kerr L. Dental problems in athletes. Clinics in sports medicine. 1983;2(1):115-122.
23. Stenger JM, Lawson EA, Wright JM, et al. Mouthguards: protection against shock. Stenger and others. The Journal of the American Dental Association. 1964;69(3):273-281.
24. Hickey JC, Morris AL, Carlson LD, et al. The relation of mouth protectors to cranial pressure and deformation. The Journal of the American Dental Association. 1967;74(3):735-740.
25. Labella CR, Smith BW, Sigurdsson A. Effect of mouthguards on dental injuries and concussions in college basketball. Medicine and science in sports and exercise. 2002;34(1):41-44.
26. Wisniewski JF, Guskiewicz K, Trope M, et al. Incidence of cerebral concussions associated with type of mouthguard used in college football. Dental traumatology. 2004;20(3):143-149.
27. Urbanowicz M. Alteration of vertical dimension and its effect on head and neck posture. CRANIO®. 1991;9(2):174-179.
28. Aubry M, Cantu R, Dvorak J, et al. Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001. The Physician and sportsmedicine. 2002;30(2):57-63.
29. Hollis SJ, Stevenson MR, McIntosh AS, et al. Incidence, risk, and protective factors of mild traumatic brain injury in a cohort of Australian nonprofessional male rugby players. The American journal of sports medicine. 2009;37(12):2328-2333.
30. Ma W. Basketball players' experience of dental injury and awareness about mouthguard in China. Dental Traumatology. 2008;24(4):430-434.
31. Azodo CC, Odai CD, Osazuwa- Peters N, et al. A survey of orofacial injuries among basketball players. International dental journal. 2011;61(1):43-46.
32. Yeşil Duymuş Z, Gungor H. Use of mouthguard rates among university athletes during sport activities in Erzurum, Turkey. Dental traumatology. 2009;25(3):318-322.
33. Correa MB, Schuch HS, Collares K, et al. Survey on the occurrence of dental trauma and preventive strategies among Brazilian professional soccer players. Journal of applied oral science. 2010;18(6):572-576.
34. Pribble JM, Maio RF, Freed GL. Parental perceptions regarding mandatory mouthguard use in competitive youth soccer. Injury Prevention. 2004;10(3):159-162.
35. Zimmermann C, Troulis M, Kaban L. Pediatric facial fractures: recent advances in prevention, diagnosis and management. International journal of oral and maxillofacial surgery. 2005;34(8):823-833.
36. Kaban LB, Mulliken JB, Murray JE. Facial fractures in children: an analysis of 122 fractures in 109 patients. Plastic and reconstructive surgery. 1977;59(1):15-20.
37. Posnick JC, Wells M, Pron GE. Pediatric facial farctures: Evolving patterns of treatment. Journal of oral and maxillofacial surgery. 1993;51(8):836-844.
38. Zerfowski M, Bremerich A. Facial trauma in children and adolescents. Clinical oral investigations. 1998;2(3):120-124.
39. Chrcanovic BR, Abreu MHNG, Freire- Maia B, et al. Facial fractures in children and adolescents: a retrospective study of 3 years in a hospital in Belo Horizonte, Brazil. Dental Traumatology. 2010;26(3):262-270.
40. Qudah MA, Bataineh AB. A retrospective study of selected oral and maxillofacial fractures in a

group of Jordanian children. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2002;94(3):310-314.
41. Muller-Bolla M, Lupi-Pegurier L, Pedeutour P, et al. Orofacial trauma and rugby in France: epidemiological survey. Dental Traumatology. 2003;19(4):183-192.
42. Andreasen J, Ravn J. Epidemiology of traumatic dental injuries to primary and permanent teeth in a Danish population sample. International journal of oral surgery. 1972;1(5):235-239.
43. Levin L, Friedlander LD, Geiger SB. Dental and oral trauma and mouthguard use during sport activities in Israel. Dental Traumatology. 2003;19(5):237-242.
44. Petersson E, Andersson L, Sörensen S. Traumatic oral vs non-oral injuries. Swedish dental journal. 1997;21(1-2):55-68.
45. Burt CW, Overpeck MD. Emergency visits for sports-related injuries. Annals of emergency medicine. 2001;37(3):301-308.
46. Zuhal K, Semra ÖEM, Hüseyin K. Traumatic injuries of the permanent incisors in children in southern Turkey: a retrospective study. Dental Traumatology. 2005;21(1):20-25.
47. Hersberger S, Krastl G, Kühl S, et al. Dental injuries in water polo, a survey of players in Switzerland. Dental Traumatology. 2012;28(4):287-290.
48. Skaare AB, Jacobsen I. Dental injuries in Norwegians aged 7–18 years. Dental Traumatology. 2003;19(2):67-71.
49. Kırzıoğlu Z, Karayılmaz H, Ertürk MSö, et al. Epidemiology of traumatised primary teeth in the west-Mediterranean region of Turkey. International dental journal. 2005;55(5):329-333.
50. Cohenca N, Roges RA, Roges R. The incidence and severity of dental trauma in intercollegiate athletes. The Journal of the American Dental Association. 2007;138(8):1121-1126.
51. Ramos-Jorge ML, Bosco VL, Peres MA, et al. The impact of treatment of dental trauma on the quality of life of adolescents–a case-control study in southern Brazil. Dental Traumatology. 2007;23(2):114-119.
52. Glendor U, Marcenes W, Andreasen J. Classification, epidemiology and etiology. Textbook and color atlas of traumatic injuries to the teeth. 2007;4:217-254.
53. Akar GC. Mouthguards Used Against Sport Injuries. EÜ Dişhek Fak Derg. 2007;28:9-17.
54. Chapman P. Orofacial injuries and international rugby players' attitudes to mouthguards. British journal of sports medicine. 1990;24(3):156-158.
55. Takeda T, Ishigami K, Hoshina S, et al. Can mouthguards prevent mandibular bone fractures and concussions? A laboratory study with an artificial skull model. Dental traumatology. 2005;21(3):134-140.
56. Waked EJ, Caputo AA. Thickness and stiffness characteristics of custom-made mouthguard materials. Quintessence international. 2005;36(6).
57. Kumamoto DP, Maeda Y. A literature review of sports-related orofacial trauma. General dentistry. 2004;52(3):270-280; quiz 281.
58. Pinkham JR, Casamassimo P, Fields H, et al. Pediatric dentistry. Infancy through adolescence. 2005;4.
59. Takeda T, Ishigami K, Ogawa T, et al. Are all mouthguards the same and safe to use? The influence of occlusal supporting mouthguards in decreasing bone distortion and fractures. Dental traumatology. 2004;20(3):150-156.
60. Takeda T, Ishigami K, Handa J, et al. Does hard insertion and space improve shock absorption ability of mouthguard? Dental Traumatology. 2006;22(2):77-82.
61. Takeda T, Ishigami K, Nakajima K, et al. Are all mouthguards the same and safe to use? Part 2. The influence of anterior occlusion against a direct impact on maxillary incisors. Dental traumatology. 2008;24(3):360-365.
62. Handa J, Takeda T, Kurokawa K, et al. Influence of pre-laminated material on shock absorption ability in specially designed mouthguard with hard insert and space. Journal of prosthodontic research. 2011;55(4):214-220.
63. Maeda Y, Kumamoto D, Yagi K, et al. Effectiveness and fabrication of mouthguards. Dental traumatology. 2009;25(6):556-564.

64. Seals Jr RR, Morrow RM, Kuebker WA, et al. An evaluation of mouthguard programs in Texas high school football. Journal of the American Dental Association (1939). 1985;110(6):904-909.
65. Gardiner D, Ranalli DN. Attitudinal factors influencing mouthguard utilization. Dental Clinics of North America. 2000;44(1):53-65.
66. Lang B, Pohl Y, Filippi A. Knowledge and prevention of dental trauma in team handball in Switzerland and Germany. Dental traumatology. 2002;18(6):329-334.
67. Tulunoglu I, Özbek M. Oral trauma, mouthguard awareness, and use in two contact sports in Turkey. Dental Traumatology. 2006;22(5):242-246.
68. Scott J, Burke F, Watts D. A review of dental injuries and the use of mouthguards in contact team sports. British dental journal. 1994;176(8):310-314.
69. Garner DP, McDivitt E. Effects of mouthpiece use on airway openings and lactate levels in healthy college males. Compendium of continuing education in dentistry (Jamesburg, NJ: 1995). 2009;30:9-13.
70. Garner DP, Miskimin J. Effects of mouthpiece use on auditory and visual reaction time in college males and females. Compendium of Continuing Education in Dentistry (Jamesburg, NJ: 1995). 2009;30:14-17.
71. Kaufman RS. Case reports of TMJ repositioning to improve scoliosis and the performance by athletes. NY State Dental Journal. 1980;46:206-209.
72. Kaufman A, Kaufman R. An experimental study on the effects of the MORA on football players. Functional orthodontist, the. 1985;2(4):37-44.
73. Pae A, Yoo RK, Noh K, et al. The effects of mouthguards on the athletic ability of professional golfers. Dental Traumatology. 2013;29(1):47-51.
74. Amis T, Di ES, Bacha F, et al. Influence of intra-oral maxillary sports mouthguards on the airflow dynamics of oral breathing. Medicine and science in sports and exercise. 2000;32(2):284-290.
75. Delaney JS, Montgomery DL. Effect of noncustom bimolar mouthguards on peak ventilation in ice hockey players. Clinical Journal of Sport Medicine. 2005;15(3):154-157.
76. Keçeci AD, Çetin C, Eroğlu E, et al. Do custom-made mouth guards have negative effects on aerobic performance capacity of athletes? Dental Traumatology. 2005;21(5):276-280.
77. Cetin C, Keçeci AD, Erdoğan A, et al. Influence of custom-made mouth guards on strength, speed and anaerobic performance of taekwondo athletes. Dental Traumatology. 2009;25(3):272-276.

Chapter 13

MID-FACIAL ANATOMY USING CONE-BEAM COMPUTED TOMOGRAPHY

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INTRODUCTION

Technological advances in imaging are continually developing and are likely to affect the work of radiologists. Maxillofacial Radiologists (MFR) have been strongly involved in the evaluation of these technological developments. The introduction of Cone-beam Computed Tomography (CBCT) in dentistry has created a new challenge for MFRs whose training has predominantly been based on anatomical and pathological models of jaws, but with limited experience in midface structures. Thereby, the field of oral and maxillofacial radiology has expanded and these radiologists need to be trained in the evaluation of images to maximize clinical effectiveness. MFRs are considered to be clinical specialists and are required to contribute sufficiently towards patient care. Therefore, they have to develop and maintain the level of competence required for the evaluation of the entire maxillofacial region in order to offer the service that the clinical question needs [1, 2]. This necessitates a sound knowledge of radiographic anatomy to evaluate the patient's structures in 3-dimensions. In the present chapter, a description of the anatomic details of jaws and teeth have been excluded from reviews of mid-face CBCT imaging anatomy since dentists are well-versed with the anatomic details of the jaws and teeth.

ANATOMICAL REVIEW OF THE SKULL

The skull (cranium), which has a highly complex structure, consists of two sets of bones: facial bones and cranial bones (skull base). The paranasal sinuses are the four paired sets of air-filled cavities in certain bones of the skull including maxilla, ethmoid, frontal and sphenoid.

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REFERENCES

1. Carter L, Farman AG, Geist J, Scarfe WC, Angelopoulos C, Nair MK, et al. American Academy of Oral and Maxillofacial Radiology executive opinion statement on performing and interpreting diagnostic cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106(4):561–62
2. Miracle AC, Mukherji SK. Conebeam CT of the head and neck, part 2: clinical applications. AJNR Am J Neuroradiol. 2009;30(7):1285-92
3. Rohen JW, Yokochi C, Lütjen-Drecoll E. Anatomie des Menschen fotografischer Atlas der systematischen und topografischen Anatomie. 4te Auflage, Stuttgart; New York: Schattauer 1998. ISBN 3-7495-1790-3
4. Maliborski A, Różycki R. Diagnostic imaging of the nasolacrimal drainage system. Part I. Radiological anatomy of lacrimal pathways. Physiology of tear secretion and tear outflow. Med Sci Monit. 2014;17(20):628-638
5. Karlin JN, Mustak H, Gupta A, Ramos R, Rootman DB. Cone Beam Computerized Tomography Dacryocystography (CBCT DCG) for the Evaluation of Lacrimal Drainage System Dysfunction. Ophthal Plast Reconstr Surg, 2020;36(6):549-552
6. Simmen D, Veerasigamani N, Briner HR, Jones N, Schuknecht B. Anterior maxillary Wall and lacrimal duct relationship – CT analysis for prelacrimal access to the maxillary sinus.Rhinology 2017;55(2):170-174
7. Tim D. White, Pieter A. Folkens. Skull in The Human Bone Manual, 2005. p. 75-126. https://doi.org/10.1016/B978-0-12-088467-4.50010-7
8. Yanagisawa E. Endoscopic view of the middle turbinate. Ear Nose Throat J 1993;72(11):725–27
9. Reddy UD, Dev B. Pictorial essay: Anatomical variations of paranasal sinuses on multidetector computed tomography-How does it help FESS surgeons?. Indian J Radiol Imaging. 2012;22(4):317-24
10. Chong VFH, Fan YF, Lau D, et al; Functional cndoscopic sinus surgery (FESS): What radiologists need to know. Clin Radial. 1998;53(9): 650-658
11. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H. Paranasal sinuses: CT imaging requirements for endoscopic surgery. Radiology. 1987;163(3):769-75
12. Lloyd GA, Lund VJ, Scadding GK. CT of the paranasal sinuses and functional endoscopic surgery: a critical analysis of 100 symptomatic patients. J Laryngol Otol. 1991;105(3):181-5
13. Gupta AK, Bansal S, Sahini D. Anatomy and its Variations for endoscopic sinus surgery. Clin Rhinol An Int J 2012;5(2): 55-62
14. Stammberger H, Lund V. Anatomy of the nose and paranasal sinuses. In: Gleeson M, Browning GG, Burton MJ, et al., editors. Scott-Brown's Otorhinolaryngology, head and neck surgery, vol 2., 7th ed. London: Hodder Arnold; 2008. p. 1315-1343
15. Huang BY, Lloyd KM, DelGaudio JM, Jablonowski E, Hudgins PA. Failed endoscopic sinus surgery: spectrum of CT findings in the frontal recess. Radiographics. 2009;29(1):177-195
16. Kasper KA. Nasofrontal connections. A study based on one hundred consecutive dissections. Arch Otolaryngol. 1936;23(3):322–344
17. Landsberg R, Friedman M. A computerassisted anatomical study of the nasofrontal region. Laryngoscope. 2001;111(12): 2125-2130
18. Amene C, Cosetti M, Ambekar S, Guthikonda B, Nanda A. Johann Christian Rosenmüller (1771-1820): A Historical Perspective on the Man behind the Fossa. J Neurol Surg B Skull Base. 2013;74(4): 187–193
19. Amit ND Dwivedi, Kapil K Singha. CT of the Paranasal Sinuses: Normal Anatmoy, Variants and Pathology. Journal of Optoelectronics and Biomedical Materials 2010;2(4): 281-89
20. Daniels D, Mafee MF, Smith MM, Smith TL, Naidich TP, Brown WD, et al. The Frontal Sinus Drainage Pathway and Related Structures. AJNR 2003;24(8): 1618-1627
21. Parmar H, Gujar S, Shah G, Mukherji SK. Imaging of the anterior skull base. Neuroimaging Clin N Am. 2009;19(3):427-439
22. Borges A. Imaging of the central skull base. Neuroimaging Clin N Am. 2009;19(4):669-696

23. Vinodkumar Velayudhan, Michael D. Luttrull, Thomas P. Naidich. Sella Turcica and Pituitary Gland. In Imaging of the Brain E.Book: Expert Radiology Series. Philadelphia: Saunders Elsevier;2013. Chapter 14. p. 272-297

24. Souza SA, Souza MMA, Idagawa M, Wolosker AMB, Ajzen SA. Computed tomography assessment of the ethmoid roof: a relevant region at risk in endoscopic sinus surgery. Radiol Bras. 2008;41(3):143–147

25. *Savvateeva DM, Güldner C, Murthum T, Bien S, Teymoortash* A*, Werner JA, Bremke M.* Digital volume tomography (DVT) measurements of the olfactory cleft and olfactory fossa. 2010;130(3): 398-404

26. Kainz J, Stammberger H. The roof of the anterior ethmoid: a locus minoris resistentiae in the skull base. Laryngol Rhinol Otol (Stuttg). 1988;67(4):142–149

27. Stammberger HR, Kennedy DW. Anatomic Terminology Group. Paranasal sinuses: anatomic terminology and nomenclature. Ann Otol Rhinol Laryngol Suppl. 1995;167:7–16

28. Keros P.On the practical value of differences in the level of the lamina cribrosa of the ethmoid]. Z Laryngol Rhinol Otol. 1962;41:809-813

29. Messerklinger W. Role of the lateral nasal wall in the pathogenesis, diagnosis and therapy of recurrent and chronic rhinosinusitis. Laryngol Rhinol Otol (Stuttg). 1987;66(6): 293-299

30. S. J. Zinreich, H. Stammberger, W. Bolger, M. Solaiyappan, M. Ishii. Advanced CT imaging demonstrating the bulla lamella and the basal lamella of the middle turbinate as endoscopic landmarks for the anterior ethmoid artery. Rhinology Online, 2019;2:32–43. http://doi.org/10.4193/RHINOL/18.082

31. Lund VJ, Lund VJ, Stammberger H, Fokkens WJ, Beale T, Bernal-Sprekelsen M, et al. European position paper on the anatomical terminology of the internal nose and paranasal sinuses. Rhinol Suppl. 2014;24:1-34

32. Wormald PJ. The agger nasi cell: the key to understanding the anatomy of the frontal recess. Otolaryngol Head Neck Surg 2003;129(5):497-507

33. Orhan M, Saylam CY. Anatomical analysis of the prevalence of agger nasi cell in the Turkish population. Kulak Burun Bogaz Ihtis Derg. 2009;19(2):82-86

34. Mathew R, Omami G, Hand A, Fellows D, Lurie A. Cone beam CT analysis of Haller cells: prevalence and clinical significance. Dentomaxillofac Radiol 2013;42(9):20130055.

35. Bent JP, Cuilty-Siller C, Kuhn FA. The frontal cell as a cause of frontal sinus obstruction. Am. J. Rhinol. 1994;8:185-191

36. Wormald PJ, Hoseman W, Callejas C, et al. The International Frontal Sinus Anatomy Classification (IFAC) and Classification of the Extent of Endoscopic Frontal Sinus Surgery (EFSS). Int Forum Allergy Rhinol. 2016;XX:1-19.

37. Pe´rez-Pin~as I, Sabate J, Carmona A, Catalina-Herrera CJ, Jime´nez-Castellanos J. Anatomical variations in the human paranasal sinus region studied by CT. J Anat 2000;197:221–227

38. Rezende GL, Soares VY, Moraes WC, Oliveira CA, Nakanishi M. The sphenopalatine artery: a surgical challenge in epistaxis. Braz J Otorhinolaryngol. 2012;78(4):42-47.

39. Yamamoto H, Nomura K, Hidaka H, Katori Y, Yoshida N. Anatomy of the posterior and middle ethmoidal arteries via computed tomography. SAGE Open Med. 2018;6: 2050312118772473

40. Laine FJ, Nadel L, Braun IF. CT and MR Imaging of the Central Skull Base. Radiographics 1990; 10:591-602

41. Albert L. Rhoton, 10 - Surgical Anatomy of the Sellar Region. Editor(s): Edward R. Laws, Giuseppe Lanzino, Transsphenoidal Surgery, W.B. Saunders; 2010. p. 92-119, ISBN 9781416002925

42. Ginsberg LE, Pruett SW, Chen MY, Elster AD. Skull base foramina of the middle cranial fossa: reassessment of normal variation with high resolution CT. AJNR Am J Neuroradiol. 1994;15(2):283-291

43. Mohebbi A, Rajaeih S, Safdarian M, Omidian P. The sphenoid sinus, foramen rotundum and vidian canal: a radiological study of anatomical relationships. Braz J Otorhinolaryngol. 2017;83(4):381-387

44. Tashi S, Purohit BS, Becker M, Mundada P. The pterygopalatine fossa: imaging anatomy, communications, and pathology revisited. Insights Imaging. 2016;7(4):589-599

45. Khan AA, Asarı MA, Hassan A. Anatomic Variants of Foramen Ovale and Spinosum in Human Skulls. Int. J. Morphol. 2012;30(2):445-449
46. *Tauber M, van Loveren HR, Jallo G, Romano A, Keller JT. "The enigmatic foramen lacerum".* Neurosurgery. 1999;44(2):386-391
47. Curtin HD, Chavali R. Imaging of the skull base. Radiol Clin North Am. 1998;36(5):801-817