Chapter 2

Orthodontics and Oral, Dental, and Maxillofacial Radiology: Multidisciplinary Treatments and Contemporary Approaches

Gizem Yazdan Özen[1]

Abstract

The discovery of X-rays by Wilhelm Roentgen was a groundbreaking development in medical history. This revolutionary discovery was quickly adopted in dentistry, making radiographic imaging an indispensable tool for diagnosis and treatment processes. Initially, radiology education was provided by medical professionals, but over time, it was integrated into the field of dentistry.

Radiographic imaging, which began with manual methods, has largely transitioned to digital systems today. Particularly in oral, dental, and maxillofacial radiology and orthodontics, these two fundamental disciplines complement each other in diagnosing and treating complex cases. In orthodontic treatment planning, radiological imaging provides a detailed assessment of bone structures, tooth positions, and jaw relationships, guiding the treatment process.

Advanced imaging techniques such as digital radiography, cone-beam computed tomography (CBCT), and magnetic resonance imaging (MRI) have become prominent. These technologies enable more precise diagnoses and allow for the development of highly personalized treatment plans. The integration of orthodontics and oral, dental, and maxillofacial radiology has significantly advanced diagnostic and treatment processes in modern dentistry.

The discovery of X-rays by Wilhelm Conrad Roentgen in 1895 marked a revolution in medical history. Roentgen captured an image of his wife's hand using a 15-minute exposure and was awarded the Nobel Prize in

1 Asst.Prof.Dr, Kafkas University Faculty of Dentistry, Department of Orthodontics
dtgzmyazdan@gmail.com, ORCID ID: 0000-0002-8875-8267

https://doi.org/10.58830/ozgur.pub733.c3054

Physics in 1901 for his groundbreaking discovery (Fields Jr & Goaz, 1995; Ozden & Ünver, 1946).

Shortly after Roentgen's discovery, this new invention gained attention worldwide, including in Türkiye. Articles were published in daily newspapers to inform the public about X-rays. The first individuals to work with X-rays were photographers and physicists (Fields Jr & Goaz, 1995). In Türkiye, the first use of X-rays in medicine occurred in 1896 when Captain Dr. Esat Feyzi Bey and Captain Dr. Rifat Osman Bey at the Military Medical School captured an image of a student's hand. In 1897, during the Ottoman-Greek War, these doctors used Crooks tubes to locate bone fractures and bullets in wounded soldiers (Ozden & Ünver, 1946; Pırnar & Dicle, 1995).

However, the introduction of X-rays into dentistry in Türkiye was not as rapid as in medicine. In 1924, dentists Hasan Hayri Bey and Sezai Zühtü Bey submitted a report to the Ministry of Health, which led to the acquisition of an X-ray device for a dental school. Despite acquiring the device, the first radiology department was established in a separate building in the dental school's garden under the directive of Professor Server Hilmi Bey. The department was led by Hüseyin Talat Bey and later separated from the school following the university reform of 1933 (Canger & Çelenk, 2012).

Radiology courses were incorporated into the dentistry curriculum in 1927. Dr. Mehmet Selahattin Erk was assigned to teach radiology to both medical and dental students (Erden, 1948; Gürkan, 1951).

With technological advancements, imaging methods in dentistry have evolved from printed images to digital systems, making them essential tools in diagnosis and treatment planning. Digital imaging offers advantages such as high-resolution images, real-time assessment, and efficient storage of patient records. Additionally, innovations such as reduced radiation exposure, three-dimensional imaging techniques, and artificial intelligence-supported analysis continue to enhance the field.

Digital radiography converts X-ray images into electrical signals. The goal of digital radiography is to detect dental diseases and provide treatment insights, much like film-based techniques that offer information about dental structures and surrounding tissues. Two main methods are used in digital imaging: direct and indirect techniques (Yeler et al., 2006).

Direct digital imaging is divided into two systems according to whether the image is formed directly on the screen after irradiation or whether there is an intermediate phase. The system with an intermediate phase is also called quasi-direct (Hintze et al., 1994).

Radiovisiography (RVG) (Trophy Radiology, France) was the first imaging technique in a direct digital radiography system and was introduced by Dr. Frances Mouyens in 1984. Since then, different imaging systems have been introduced to the market with different resolution values, matrix sizes, sensor types and pixel values while keeping the working principle the same (Parks & Williamson, 2002).

The indirect digital imaging system includes CCD cameras and computers. The working principle is that radiography provides scanning with a CCD camera and directs it to the computer screen, where it is displayed on the computer screen (Yeler et al., 2006).

1.Radiological Imaging Tools Used in Dentistry and Orthodontics

Accurate diagnosis and effective treatment planning in dentistry rely heavily on imaging techniques. The evolution from traditional radiographic techniques to digital systems has brought significant advancements, allowing for the evaluation of not only teeth and surrounding tissues but also bone structures, sinuses, joints, and soft tissues. Key developments such as reduced radiation doses, high-resolution imaging, and widespread use of three-dimensional imaging have improved diagnostic accuracy.

Today, the following imaging methods are commonly used in dentistry for diagnostic and therapeutic purposes:

- Panoramic Radiography
- Digital Periapical Radiographs
- Occlusal Radiographs
- Lateral Cephalometric Radiography
- Antero-posterior Cephalometric Radiography
- Postero-anterior Cephalometric Radiography
- Hand-Wrist Radiographs
- Cone-Beam Computed Tomography (CBCT)
- Ultrasound Imaging
- Magnetic Resonance Imaging (MRI)

1.1. Lateral Cephalometric Radiographs

Lateral cephalometric films, which are essential for a comprehensive and detailed orthodontic treatment planning, should be taken only when necessary, like all radiographic records. The relationship and analysis of all structures in the cranial region from the films taken helps to determine the diagnosis and treatment method.(Proffit & Fields, 2013) (Figure 1)

In their 1992 study, Atchison et al. reported that orthodontic treatments can change the treatment planning by approximately 20% with the analysis of lateral cephalometric films. (Atchison et al., 1992) Today, this rate is still acceptable. Most of the anomalies present in individuals may be masked by the surrounding soft and/or hard tissues and this may lead to misleading treatment plans.

In cases where lateral cephalometric films are used as follow-up films, they are also known to be helpful treatment tools in determining the direction and speed of growth and/or the course of treatment.

Figure 1. Lateral Cephalometric film

1.2.Cephalometric Analysis

The main purpose of cephalometric films is to guide the orthodontist in diagnosis and treatment by determining the conditions that occur as a result of dental, skeletal and/or combination of these problems in patients.(Figure 2)

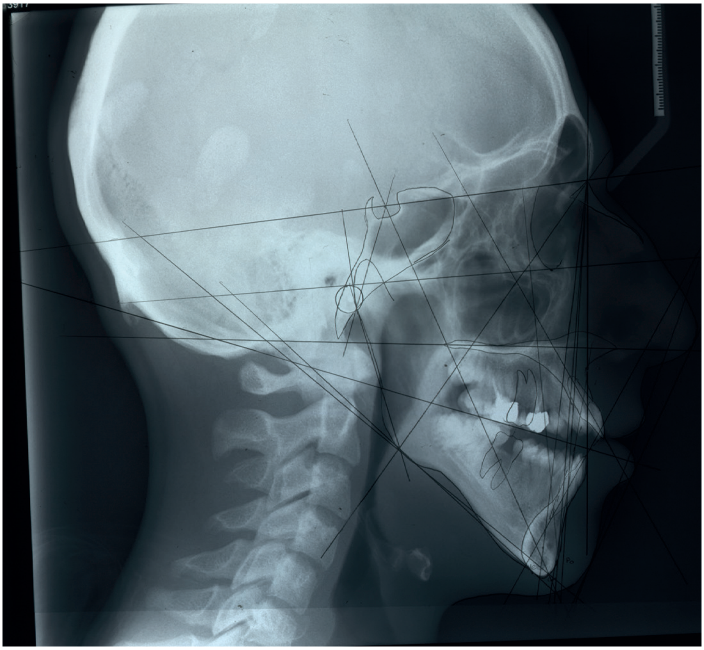

Figure 2. A manually prepared cephalometric drawing

Cephalometric analysis was first popularized by Down's after World War II. Although it was initially difficult to establish norms for reference values, this was overcome by calculating reference values for individuals with perfect facial proportions and occlusion (Proffit & Fields, 2013).

Analyses such as Down's (Downs, 1956), Steiner (Steiner, 1953), Wits (Jacobson, 1976), Jarabak, Sassouni (Sassouni, 1958) are still relevant and actively used today.

The Steiner analysis was the first orthodontic analysis developed by Cecil Steiner in the 1950s. In the analysis, he prepared not only individual measurements but also a treatment plan that guides the comparison of these measurements. In his analysis, he mentioned the orthodontically important SNA, SNB and ANB, which indicates the relationship between the jaws. He also utilized angular and linear measurements of the upper incisor NA and lower incisor NB to evaluate the protrusion of the incisors. (Steiner, 1953)

Down's analysis (Downs, 1956) is a measurement consisting of five skeletal and five dental measurements without soft tissue measurement and treatment plan. The skeletal measurements examine the position of the maxilla and mandible relative to each other and to the cranium, while the dental measurements examine the relationship of the teeth to each other and to the jaw bones.

Tweed analysis begins with three planes that form the triangle known as the Tweed triangle. These planes are the Frankfort horizontal plane, the mandibular plane, and the plane formed by the long axis of the lower incisor (Jain et al., 2017). The Frankfort plane is drawn using the midpoint of the skeletal orbital points on both sides as a reference, along with a point 4.5 mm above the geometric center of the ear rod. The mandibular plane is drawn tangentially along the lower border of the mandible. The third plane is drawn using the long axis of the lower incisor as a reference. By combining these three planes, the Tweed triangle is formed. The three angles located at the three vertices of this triangle serve as references for the evaluation in this analysis. These angles are called FMA, FMIA, and IMPA.

1.3.Postero-Anterior Radiographs

Unlike lateral radiographs, frontal radiographs are used to determine maxilla, mandible and various facial asymmetries and to evaluate vertical directional measurements in the craniofacial region and oral structures (Jacobson, 1995). When used in conjunction with lateral cephalometric evaluations, they can be informative for the craniofacial and dentofacial complex in all 3 dimensions (Athanasiou, 1995)

Although postero-anterior radiographs are one of the leading 2D imaging methods used by orthodontists in facial asymmetries, they are not preferred by clinicians (Figure 3). In the literature, this radiography group has been used in the evaluation of syndromes and craniofacial asymmetry (Grummons et al., 1987; Svanholt & Solow, 1977).

Figure 3. Postero-anterior cephalometric radiography

1.4.Panoramic Radiographs

Panoramic (orthopantomography) radiographs are the most commonly used radiographs in dentistry to visualize the maxilla and mandible and dental structures on a single film (Koç & Özbek, 2021) (Figure 4). Nowadays, it is known that almost every dental clinic has at least one radiography device.

In Panoramic radiographs;

- Teeth,

- Maxilla

- Maxillary sinus

- Mandibular

- Nasal septum,

- Nasal cavity,

- Zygomatic arc,

- Orbital base,

- Articular eminence,

- Styloid processes,

- Cervical vertebrae,

- Hyoid bone,

- Nasal soft tissue,

- Soft palate,

- Uvula,

- Tongue,

- Nasopharyngeal,

- Glossopharyngeal and palatoglossal airways can be monitored.

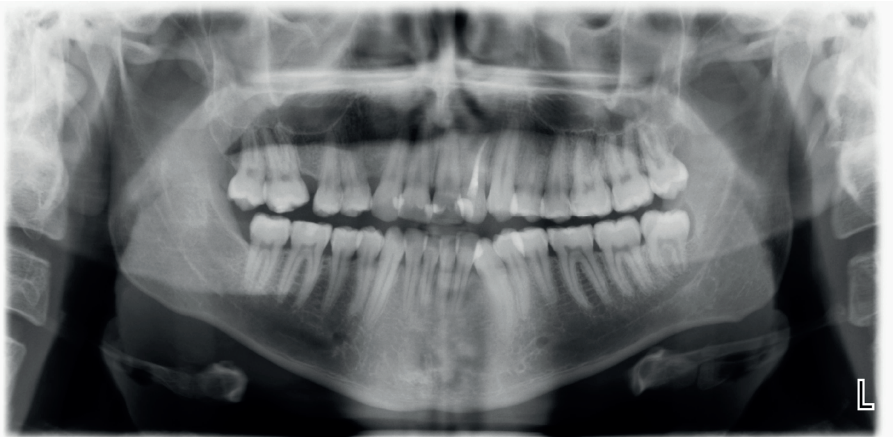

Figure 4. Panoramic Radiography

1.5.Digital Periapical Radiographs

Periapical radiographs perform imaging in a more specific area than other radiographs. They provide a detailed representation of the relationships of the teeth with the crown, root and surrounding tissues (Özcan, 2017).

The aim of use in orthodontics is;

- Evaluation of the development, eruption time and position of teeth
- Dimensions of the teeth, assessment of the presence of shape anomalies
- Evaluation of root resorption of deciduous teeth in deciduous and/or mixed dentition
- Evaluation of root formation stages of permanent teeth

- Evaluation of the inclination of the tooth roots.

1.6.Occlusal Radiographs

It is a film group that helps to see the teeth and jaw bases in the upper and lower jaw in a single film. It can be used to monitor erupting teeth, fractures in the maxilla or mandible, determine the position of plus teeth, evaluate soft and/or hard tissue problems, and control the separation of the suture palatine media to control the skeletal change of the maxillary expansion appliance. (Scheller-Sheridan, 2013) (Figure 5).

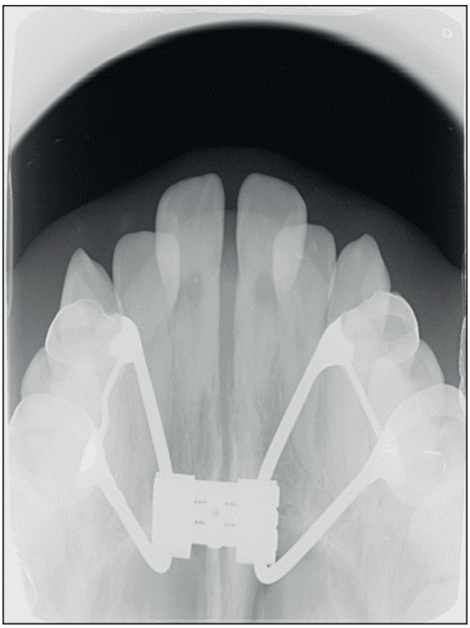

Figure 5. Example of occlusal radiograph

1.7.Cone Beam Computed Tomography (CBCT)

Towards the end of the 1960s, computed tomography was first used in the UK (Hounsfield, 1973). The first clinical application was performed by Dr. James Ambrose (Ambrose, 1973).The examination of craniofacial structures was first performed by Mozzo and colleagues (Mozzo et al., 1998).

The scanning process can be performed standing, sitting and/or lying down (Caloss et al., 2007; Scarfe & Farman, 2008), the artifact has a less clear image (Scarfe & Farman, 2008), the scanning time is short (Scarfe &

Farman, 2008; Scarfe et al, 2010), the data obtained are in DICOM (Digital Imaging and Communications in Medicine) format (Kau et al., 2009) and can be transferred to an external memory (White & Pharoah, 2008) are among the advantages of cone beam computed tomography.

It is known that the images obtained with CBCT are identical to the original images (Lagravère et al., 2008). This provides more precise and reliable results. It can also be used to determine the status of the anomaly and the depth of the defect in individuals with cleft lip and palate (Baba et al., 2002) and to evaluate the effect of rapid upper jaw expansion on the respiratory tract (Garrett et al., 2008; Lagravère et al., 2010; Lagravère et al., 2008). CBCT is also used in the construction and evaluation of dental implants.

CBCT is currently used for various purposes in all branches of dentistry and is gradually replacing other radiographic imaging techniques.

1.8.Hand-Wrist Radiographs

Wrist radiographs were recorded shortly after the discovery of X-rays and started to be used in the assessment of skeletal development. The main reason for their use in the evaluation of skeletal development is that as many bones with ossification periods as possible can be visualized together in a single film and these films can be obtained more easily than other parts of the body.(Figure 6)

Figure 6. Example of a wrist radiograph

1.9. Ultrasonography

It can be defined as mechanical energy consisting of acoustic waves at frequencies higher than the hearing level of the human ear. In medicine for diagnostic purposes, it is generally preferred in cases such as pregnancy where radiation applications are harmful (Atıcı & Ertaş, 2014).

Ultrasound can be used in various fields in dentistry. The main ones are evaluation of orthodontic root resorption (El-Bialy et al., 2004), treatment of temporomandibular joint disorders (Erickson, 1964), periodontal healing (Ikai et al., 2008).

Insufficient mandibular growth can lead to impaired dental occlusion and deformations in facial aesthetics (Proffit et al., 2006). In cases of advanced mandibular insufficiency, the main treatment options are orthognathic surgery or distraction osteogenesis (Molina, 2009), and functional appliances may be preferred to prevent complications related to surgery (Moulin-Romsée et al., 2004). There is a need for alternative methods that can provide faster and more effective results in the treatment of mandibular insufficiency. In this context, studies evaluating the effectiveness of low-intensity intermittent ultrasound are limited (Khan et al., 2013). El-Bialy et al. examined the effectiveness of low-intensity intermittent ultrasound on mandibular growth and reported that the growth was higher in the applied group (El-Bialy et al., 2006). Oyonarte et al. reported that low-intensity intermittent ultrasound affects mandibular growth at the bone and cartilage level (Oyonarte et al., 2013).

1.10. Magnetic Resonance Imaging (MRI)

It works in a completely different structure than other imaging systems. It works on the principle that water molecules in tissues move as a result of radio waves (Brooks & Miles, 1993; Edwards, 1993).

Since it is a noninvasive technique, it is widely used in dentistry. However, although it is a sensitive technique, its specificity is not as high.

MRI has many advantages:

- It does not emit ionizing radiation
- It can be used for soft tissue examination
- It allows cross-sectional examination of images (Kondoh et al., 1998; Nebbe et al., 1998)

Although it is mostly used in temporamandibular joint imaging in dentistry, it can also be used in cases of cleft lip and palate, cysts and malignant lesions in the maxillofacial region (Edwards, 1993).

1.11.Stereophotogrammeters

The basis of stereophotogrammetry is the steroscopic vision principle that exists in all living things in nature. According to this principle, the third dimensions of the objects existing in nature are overcome by visual perception from different angles and objects are perceived in 3D. Stereophotogrammetry is based on obtaining a 3D image by combining images taken with at least 2 imaging devices at equal distances from the object (Görgülü et al., 2015; Ras et al., 1995; Tzou & Frey, 2011)

In today's technology, it is ideally used in the examination of soft tissues (Görgülü et al., 2015; Kau et al., 2010).

In the field of orthodontics, it is used;

- When analyzing soft tissue differences by age race sex (Tanikawa et al., 2016)
- In smile aesthetic evaluations (van der Meer et al., 2014)
- In 3D soft tissue image archives of individuals (Rosati et al., 2010; van der Meer et al., 2014)
- In asymmetry assessments (Edler et al., 2003)
- In omage comparisons before and after treatment,(Rosati et al., 2010)
- In Growth and development studies (Wong et al., 2008)
- In the assessment of various syndromes (Fourie et al., 2011).

References

Ambrose, J. (1973). Computerized transverse axial scanning (tomography): Part 2. Clinical application. *The British journal of radiology*, *46*(552), 1023-1047.

Atchison, K. A., Luke, L. S., & White, S. C. (1992). An algorithm for ordering pretreatment orthodontic radiographs. *American journal of orthodontics and dentofacial orthopedics*, *102*(1), 29-44.

Athanasiou, A. E. (1995). Orthodontic cephalometry. *(No Title)*.

Atıcı, M. Y., & Ertaş, E. T. (2014). DİŞ HEKİMLİĞİNDE DÜŞÜK YOĞUNLUKLU KESİKLİ ULTRASON KULLANIMI. *Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi*, *25*, 142-150.

Baba, R., Konno, Y., Ueda, K., & Ikeda, S. (2002). Comparison of flat-panel detector and image-intensifier detector for cone-beam CT. *Comput Med Imaging Graph*, *26*(3), 153-158.

Brooks, S. L., & Miles, D. A. (1993). Advances in diagnostic imaging in dentistry. *Dental Clinics of North America*, *37*(1), 91-111.

Caloss, R., Atkins, K., & Stella, J. P. (2007). Three-dimensional imaging for virtual assessment and treatment simulation in orthognathic surgery. *Oral and maxillofacial surgery clinics of North America*, *19*(3), 287-309.

Canger , E. M., & Çelenk , P. (2012). Türk Diş Hekimliği Radyolojisinde Bir Öncü: Dt. Galip Abdi Rona (1900-1958). *Turkiye Klinikleri Journal of Medical Ethics-Law and History*, *20*(3), 193-197.

Downs, W. B. (1956). Analysis of the dentofacial profile. *The Angle Orthodontist*, *26*(4), 191-212.

Edler, R., Wertheim, D., & Greenhill, D. (2003). Comparison of radiographhic and photographic measurement of mandibular asymmetry. *American journal of orthodontics and dentofacial orthopedics*, *123*(2), 167-174.

Edwards, M. K. (1993). Magnetic resonance imaging of the head and neck. *Dental Clinics of North America*, *37*(4), 591-611.

El-Bialy, T., El-Shamy, I., & Graber, T. M. (2004). Repair of orthodontically induced root resorption by ultrasound in humans. *American journal of orthodontics and dentofacial orthopedics*, *126*(2), 186-193.

El-Bialy, T., Hassan, A., Albaghdadi, T., Fouad, H. A., & Maimani, A. R. (2006). Growth modification of the mandible with ultrasound in baboons: a preliminary report. *American journal of orthodontics and dentofacial orthopedics*, *130*(4), 435. e437-435. e414.

Erden, F. (1948). *Türk hekimleri biyografisi*. Çituri Biraderler Basımevi.

Erickson, R. I. (1964). Ultrasound—a useful adjunct in temporomandibular joint therapy. *Oral Surgery, Oral Medicine, Oral Pathology*, *18*(2), 176-179.

Fields Jr, R., & Goaz, P. (1995). Notes on the history of dental radiology. *Texas dental journal*, *112*(2), 15-22.

Fourie, Z., Damstra, J., Gerrits, P. O., & Ren, Y. (2011). Evaluation of anthropometric accuracy and reliability using different three-dimensional scanning systems. *Forensic science international*, *207*(1-3), 127-134.

Garrett, B. J., Caruso, J. M., Rungcharassaeng, K., Farrage, J. R., Kim, J. S., & Taylor, G. D. (2008). Skeletal effects to the maxilla after rapid maxillary expansion assessed with cone-beam computed tomography. *American journal of orthodontics and dentofacial orthopedics*, *134*(1), 8. e1-8. e11.

Görgülü, S., Duran, G., & Dindaroğlu, F. (2015). Güncel Bilgiler Işığında Ortodonti (1. Baskı). *Erhan Özdiler, Gümüş Kitabevi, Ankara*, 367-381.

Grummons, C, D., Van de Coppello, & Kappeyne, M. (1987). A frontal asymmetry analysis. *Journal of clinical orthodontics: JCO*, *21*(7), 448-465.

Gürkan, S. (1951). Dişhekimliği röntgen bilgisi. *İstanbul: Dişhekimliği Alemi Mecmuası yayını*, 4-6.

Hintze, H., Wenzel, A., & Jones, C. (1994). In vitro comparison of D-and E-speed film radiography, RVG, and visualix digital radiography for the detection of enamel approximal and dentinal occlusal caries lesions. *Caries research*, *28*(5), 363-367.

Hounsfield, G. N. (1973). Computerized transverse axial scanning (tomography): Part 1. Description of system. *The British journal of radiology*, *46*(552), 1016-1022.

Ikai, H., Tamura, T., Watanabe, T., Itou, M., Sugaya, A., Iwabuchi, S., Mikuni-Takagaki, Y., & Deguchi, S. (2008). Low-intensity pulsed ultrasound accelerates periodontal wound healing after flap surgery. *Journal of periodontal research*, *43*(2), 212-216.

Jacobson, A. (1976). Application of the" Wits" appraisal. *American journal of orthodontics*, *70*(2), 179-189.

Jacobson, A. (1995). Radiographic cephalometry: from basics to videoimaging. *(No Title)*.

Jain, S., Tondon, R., Singh, K., Kulshrestha, R., & Umale, V. (2017). Tweed's Philosophy-A Review. *Indian Journal of Orthodontics and Dentofacial Research*, *3*(4), 198-206.

Kau, C. H., Božič, M., English, J., Lee, R., Bussa, H., & Ellis, R. K. (2009). Cone-beam computed tomography of the maxillofacial region—an update. *The international Journal of medical robotics and computer assisted surgery*, *5*(4), 366-380.

Kau, C. H., Richmond, S., Zhurov, A., Ovsenik, M., Tawfik, W., Borbely, P., & English, J. D. (2010). Use of 3-dimensional surface acquisition to study facial morphology in 5 populations. *American journal of orthodontics and dentofacial orthopedics*, *137*(4), S56. e51-S56. e59.

Khan, I., El-Kadi, A. O., & El-Bialy, T. (2013). Effects of growth hormone and ultrasound on mandibular growth in rats: microCT and toxicity analyses. *Archives of oral biology*, *58*(9), 1217-1224.

Koç, N., & Özbek, Ş. (2021). Panoramik Radyografi. In (Vol. 10, pp. 75-76): Ankara Diş Hekimleri Odası.

Kondoh, T., Westesson, P.-L., Takahashi, T., & Seto, K.-i. (1998). Prevalence of morphological changes in the surfaces of the temporomandibular joint disc associated with internal derangement. *Journal of oral and maxillofacial surgery*, *56*(3), 339-343.

Lagravère, M. O., Carey, J., Heo, G., Toogood, R. W., & Major, P. W. (2010). Transverse, vertical, and anteroposterior changes from bone-anchored maxillary expansion vs traditional rapid maxillary expansion: a randomized clinical trial. *American journal of orthodontics and dentofacial orthopedics*, *137*(3), 304. e301-304. e312.

Lagravère, M. O., Carey, J., Toogood, R. W., & Major, P. W. (2008). Three-dimensional accuracy of measurements made with software on cone-beam computed tomography images. *American journal of orthodontics and dentofacial orthopedics*, *134*(1), 112-116.

Molina, F. (2009). Mandibular distraction osteogenesis: a clinical experience of the last 17 years. *Journal of Craniofacial Surgery*, *20*(8), 1794-1800.

Moulin-Romsée, C., Verdonck, A., Schoenaers, J., & Carels, C. (2004). Treatment of hemifacial microsomia in a growing child: the importance of co-operation between the orthodontist and the maxillofacial surgeon. *Journal of Orthodontics*, *31*(3), 190-200.

Mozzo, P., Procacci, C., Tacconi, A., Tinazzi Martini, P., & Bergamo Andreis, I. (1998). A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. *European radiology*, *8*(9), 1558-1564.

Nebbe, B., Brooks, S., Hatcher, D., Hollender, L., Prasad, N., & Major, P. (1998). Interobserver reliability in quantitative MRI assessment of temporomandibular joint disk status. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, *86*(6), 746-750.

Oyonarte, R., Becerra, D., Díaz-Zúñiga, J., Rojas, V., & Carrion, F. (2013). Morphological effects of mesenchymal stem cells and pulsed ultrasound on condylar growth in rats: a pilot study. *Australian Orthodontic Journal*, *29*(1), 3-12.

Ozden, A. M., & Ünver, A. S. (1946). Doktor Esad Feyzi merhum: bizde X reyyonu uzerine ilk arastirma, olumunun 45 inci yildonumunda ilk röntgencimiz Esad Feyzi. *Istanbul: Istanbul Universitesi Tıb Tarihi Enstitusu*.

Özcan, İ. (2017). Diş Hekimliğinde Radyolojinin Esasları: Konvansiyonelden Dijitale.

Parks, E. T., & Williamson, G. F. (2002). Digital radiography: an overview. *J Contemp Dent Pract*, *3*(4), 23-39.

Pırnar, T., & Dicle, O. (1995). *Yüz yıllık yolculuk: başlangıcından--günümüze Türk radyolojisi*. 5G Matbaacılık.

Proffit, W., & Fields, H. (2013). Concepts of growth and development. *Contemporary orthodontics*, 20-65.

Proffit, W. R., Fields Jr, H. W., & Sarver, D. M. (2006). *Contemporary orthodontics*. Elsevier Health Sciences.

Ras, F., Habets, L. L., van Ginkel, F. C., & Prahl-Andersen, B. (1995). Method for quantifying facial asymmetry in three dimensions using stereophotogrammetry. *The Angle Orthodontist*, *65*(3), 233-239.

Rosati, R., De Menezes, M., Rossetti, A., Sforza, C., & Ferrario, V. F. (2010). Digital dental cast placement in 3-dimensional, full-face reconstruction: a technical evaluation. *American journal of orthodontics and dentofacial orthopedics*, *138*(1), 84-88.

Sassouni, V. (1958). Diagnosis and treatment planning via roentgenographic cephalometry. *American journal of orthodontics*, *44*(6), 433-463.

Scarfe, W. C., & Farman, A. G. (2008). What is cone-beam CT and how does it work? *Dental Clinics of North America*, *52*(4), 707-730.

Scarfe, W. C., Farman, A. G., Levin, M. D., & Gane, D. (2010). Essentials of maxillofacial cone beam computed tomography. *The Alpha Omegan*, *103*(2), 62-67.

Scheller-Sheridan, C. (2013). *Basic guide to dental instruments*. John Wiley & Sons.

Steiner, C. (1953). Cephalometrics for you and me. am J Orthod, St. In: Louis.

Svanholt, P., & Solow, B. (1977). Assesment of midline discrepancies on the posterior cephalometric radiograph. *Trans Eur Orthod Soc*, *25*, 261-268.

Tanikawa, C., Zere, E., & Takada, K. (2016). Sexual dimorphism in the facial morphology of adult humans: a three-dimensional analysis. *Homo*, *67*(1), 23-49.

Tzou, C.-H. J., & Frey, M. (2011). Evolution of 3D surface imaging systems in facial plastic surgery. *Facial Plastic Surgery Clinics*, *19*(4), 591-602.

van der Meer, W. J., Dijkstra, P. U., Visser, A., Vissink, A., & Ren, Y. (2014). Reliability and validity of measurements of facial swelling with a stereophotogrammetry optical three-dimensional scanner. *British Journal of Oral and Maxillofacial Surgery*, *52*(10), 922-927.

White, S. C., & Pharoah, M. J. (2008). The evolution and application of dental maxillofacial imaging modalities. *Dental Clinics of North America*, *52*(4), 689-705.

Wong, J. Y., Oh, A. K., Ohta, E., Hunt, A. T., Rogers, G. F., Mulliken, J. B., & Deutsch, C. K. (2008). Validity and reliability of craniofacial anthropometric measurement of 3D digital photogrammetric images. *The Cleft Palate-Craniofacial Journal*, *45*(3), 232-239.

Yeler, D. Y., Taşveren, S. K., & Kaynar, O. (2006). Dişhekimliğinde dijital görüntüleme yöntemleri. *Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi*, *2006*(Supplement 1).