5 Additional Imaging Techniques in Pediatric Dental Practice

This chapter contains information on machines and techniques not covered in the previous chapters. However, that doesn't mean these are not used in pediatric dentistry; it is just that most of them are not available in a private dental setting, as either they are very specialized and require specially trained radiographers and technicians to operate the machines or the technology is very expensive and will only be found in hospitals. Nevertheless, pediatric dentists should be aware of these techniques and imaging modalities as they might be faced with medically compromised patients requiring this type of imaging. Just as with the techniques described and discussed in the previous chapters, every technique has its applications and indications, as well as contraindications.

5.1 Multislice Computed Tomography (MSCT)

Sir Godfrey Hounsfield invented computed tomography in 1973. Since then many improvements have been realized to increase image quality and patient comfort. Professor Willi Kalender is credited for his significant contributions to develop helical computed tomography. Commonly this technique is called "a CT." It is however very different from the cone beam computed tomography (CBCT) that was discussed in Chap. 4. Multislice CT uses a narrow fan-shaped beam, which revolves around the patient, while on the opposite side of the patient image detectors capture the image. The patient is simultaneously moved slow or fast through that X-ray field. If it is done fast, the resolution will be low, as the slices will be thicker (large pitch), whereas if the patient is moved slowly through the X-ray field, the slice thickness is thinner (smaller pitch) and hence the resolution is higher (maximum 350 μm, compared to CBCT where the highest resolution today is 70 μm). However, one has to keep in mind that the higher the resolution, the higher the radiation dose will be. These machines require the patient to lie absolutely still on a table, while the table is moved into the machine's gantry.

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At the writing of this chapter, the fourth-generation CT scanners have been developed and are referred to as stationary-rotate geometry scanners as the X-ray tube rotates within a stationary circle of detectors. Technology allows the detectors to be arranged in a continuous circular array containing as many as 40,000 individual detectors. Whereas in the past scanning time could be substantially long (minutes), today that scanning time is merely a few seconds anymore. The latter causes less movement artifacts to be present in the image, which is a great advantage. However, the resolution of the image can be affected negatively by this fast scanning, as the patient is moved faster through the gantry. Reducing the speed would increase the resolution, but also the radiation dose. It is obvious that this is a trade-off that needs to be made for the pathology one is investigating. That decision lies with the radiologist/radiographer team. An example of a CT machine is shown in Fig. 5.1.

MSCT is ideal for hard- and soft-tissue imaging and as its exposure settings and algorithms are standardized one can obtain information about the type of tissue one is assessing. The soft-tissue resolution is much better than that of CBCT and one can distinguish several tissues from one another. The technique also allows for the use of so-called Hounsfield units. These units allow for finer diagnosis in assessing the nature of a lesion or a tissue. In Table 5.1 the Hounsfield units are shown.

Fig. 5.1 An example of a CT machine (General Electric®, courtesy of GE® website)

Table 5.1 Hounsfield units for several organs and tissues

Tissue	CT number
Cortical bone	+1000
Fresh blood (trauma and hemorrhage)	+200
Muscle	+50
Brain: white matter	+45
Brain: gray matter	+40
Cerebrospinal fluid	+15
Water	0
Fat	−100
Lung	−200
Air	−1000

It is obvious that MSCT, because of its high radiation dose associated, is not an imaging modality one would order for common dental pathology, such as dentigerous cyst or radicular cyst. However, patients who suffered a severe trauma with risk of intracranial hemorrhage would benefit from being submitted for MSCT immediately after the accident, as it could save their lives, because the CT images would be able to show the bleeding.

MSCT has its place in pathology diagnosis and as such children suffering from systemic disease or pathology, involving both hard and soft tissues, would benefit from this technology (e.g., abdominal and brain tumors).

Typical effective doses from MSCT vary between 2000 and 16,000 μSv, whereas for panoramic radiography it is around 24 μSv and for CBCT it varies between 5 and 500 μSv. From these figures, it is clear that MSCT is not indicated in routine pediatric dental care. The main reason for the higher radiation doses in MSCT is the fact that MSCT uses significantly higher mA values than CBCT or two-dimensional imaging modalities.

Hybrid imaging systems combine MSCT with additional imaging modalities, such as positron-emission tomography (PET-CT) and single-photon emission computed tomography (SPECT-CT), and are used in cancer diagnosis and follow-up. The patient is therefore injected with a radiopharmaceutical (e.g., ^{18}F-2-fluoro-2-deoxy-D-glucose or Technetium 99m), which emits radiation that is picked up by a special scanner. In fact, the patient is emitting the radiation and is actually radioactive for a given time. As exponential breakdown of the radiopharmaceutical occurs, the time between injection of the radioisotope and the scan is to be accurately timed. Proper caution, in terms of contact with other people and discarding human waste, is required when patients are being injected with these products. The images acquired from the PET or SPECT are merged with the MSCT image to enable the diagnostician to accurately identify the affected organ(s) and/or the extent of the pathology (also called functional imaging). CT perfusion is another illustration of CT that is used to visualize the functional blood flow. It is obvious that all these are beyond the scope of this book.

*Medical CT is obviously not available in dental offices; however, a pediatric dentist should have enough knowledge about this technology to know when to refer a patient. In most cases, this will be coordinated with other care givers in the medical field (*e.g., *pediatrician, oncologist, ENT specialist). For common dental pathology in children medical CT will never be used. Pediatric dentists working in a hospital environment will probably be more exposed to patients who need a medical CT examination or a combination of CT and MRI (see below).*

5.2 Magnetic Resonance Imaging (MRI)

In the beginning this technique was called nuclear magnetic resonance (NMR), but the public's erroneous perception that there was a connotation with nuclear energy made the medical profession change the name to magnetic resonance imaging (MRI). This technique does not use ionizing radiation, but magnetism and the fact that hydrogen atoms, hence the original name nuclear imaging, can be influenced in their precession when a high magnetic field is applied.

The principle is to place the patient in a very strong magnetic field (1.5 or 3.0 T), several times higher than the earth's magnetic field (approximately 0.5 μT). This will have an effect on the hydrogen atoms (protons) in the human body, which can be considered as positively charged randomly spinning tops. These hydrogen atoms will respond to the high magnetic field and will start spinning in a particular direction and at a specific speed and with a particular magnitude. Since the hydrogen content is different per type of tissue in the body, every type of tissue will result in a different signal. When the magnetic field is turned off, the hydrogen atoms return to their resting state. The speed of this depends on the tissue. The software translates these returns into an image of gray values, which allows for differentiation between soft tissues very well. Therefore MRI is the preferred technology to image soft tissue and soft tissue pathology. Tissues with a lot of hydrogen atoms will give a strong signal (e.g., salivary glands are bright white) and tissues with a low amount of hydrogen will result in a low signal (e.g., cortical bone is black).

Several so-called sequences can be used, which result in images with differences in appearance of the tissues. In a T1 sequence, fat will give a high signal (white), while water will give a low signal (dark), whereas in a T2 sequence, water will give a high signal (white) as will fat. Some other examples of particular sequences that are used are spin echo, fluid-attenuated inversion recovery or FLAIR, short time inversion recovery or STIR, and turbo spin echo or TSE.

In Fig. 5.2 one can appreciate the design of the MRI machine. There is some resemblance with the MSCT machine, but as explained the technology is completely different. Caution is required when entering the MRI area in the hospital. All ferromagnetic materials need to be banned from the room and its immediate surroundings as it would cause harm to the patients and damage the machine. Since the magnetic field in the MRI is several hundred times stronger than the earth's magnetic field (30 μT near the equator and 70 μT at the poles), objects like scissors, oxygen tanks, and metal carts would be attracted into the magnet with great force. Accidents have happened and as such precaution is key when entering the zone around an MRI machine. Audible and visual signaling is always in place to announce visitors of potential risks entering the zone.

MRI in pediatric dentistry is indicated if the patient has soft tissue pathology that requires imaging (e.g., ranula) or a temporomandibular joint disorder that affects the muscles and/or condylar disc. In the latter case MRI will enable one to visualize the disc clearly (low signal as the disc does not contain as much hydrogen atoms as muscle for instance) in the joint space.

Fig. 5.2 An example of a Siemens® MRI machine (courtesy Siemens® website)

One has to keep in mind that MRI machines produce a banging sound (sometimes more than 95 decibels, which requires earplugs or headphones to be worn by the patient), which might be frightening and which may require the child to be sedated. Claustrophobia is another issue as often a mask (magnetic coils) is placed over the patient's face, which again may be a reason for the child to be sedated.

5.3 Ultrasonography

Ultrasonography or echography is another imaging modality that does not use ionizing radiation. However, compared to MRI, this machine is very cheap (millions of dollars versus thousands). This technique is probably best known for its application in OBGYN medicine to visualize the unborn child in the womb. The technique uses ultrasonic waves which are generated in a piezoelectric crystal inside the so-called transducer, which not only emits but also receives the ultrasonic waves. An example of a linear and hockey stick-type transducer is shown in Fig. 5.3.

The speed of sound is affected by the compressibility of the medium (acoustic impedance); therefore it travels faster in rigid materials which are more resistant to compression and it travels slower in fluids and gases as these are more susceptible to compression. Reflection of the sound is paramount in this technique as the sound will be reflected at boundaries of tissues. Tissues or pathology that reflect little to no sound waves will produce no "echo," hence the jargon hypoechoic or anechoic, respectively, whereas tissues or pathology that do reflect the sound waves will return an echo and will be identified as echoic or hyperechoic (high signal or white shadow).

The particular characteristics of each of the soft tissues will enable one to distinguish between them (e.g., healthy salivary gland tissue shows a homogenously gray echo, whereas muscular tissue is hypoechoic). When the ultrasound beam hits a boundary between two materials with different acoustic impedance, some of the beam will be reflected and the remainder will be transmitted.

Fig. 5.3 Example of a linear Philips® transducers (left-hand side is a traditional linear transducer and right-hand side is a hockey stick-type transducer, which can be used intraorally on the cheek or tongue for instance)

For diagnostic imaging an ultrasound frequency between 2.5 and 40 MHz (megahertz) is required. This is initiated inside the transducer, which is held in contact with the soft tissues. However, since air is a bad medium for sound, a so-called coupling agent (a gel or a gel pad) is required to ensure a good contact. If ultrasound is used intraorally, saliva or a gel pad will be the coupling agent.

The frequency affects the travel depth or penetration of the ultrasound waves. The lower the frequency, the deeper the ultrasound will travel, while the higher the frequency, the more superficial the penetration will be. The images from the latter will, however, have a higher resolution than the former.

Color Doppler is a feature in ultrasound that allows for visualization of vascularization. That is a feature that will be useful in identifying pathology (e.g., hypervascularization in a tumor) or assessing healing tissue (e.g., check blood flow after a flap or major orthognathic surgery).

The technique is very much operator dependent, which means that different pressures applied to the transducer generate different images. Variation in operators, in terms of application of amount of pressure on the patient's tissues with the transducer, will result in different images. But then again, ultrasonography does not pose any danger for the patients and can be repeated as often as needed, if one requires to check the patient again.

In the field of pediatric dentistry, ultrasonography is useful in patients with salivary gland problems (e.g., sialolith, mumps), muscular issues, and hypertrophy of lymph nodes (lymphadenopathy). Since it requires special training and is not often

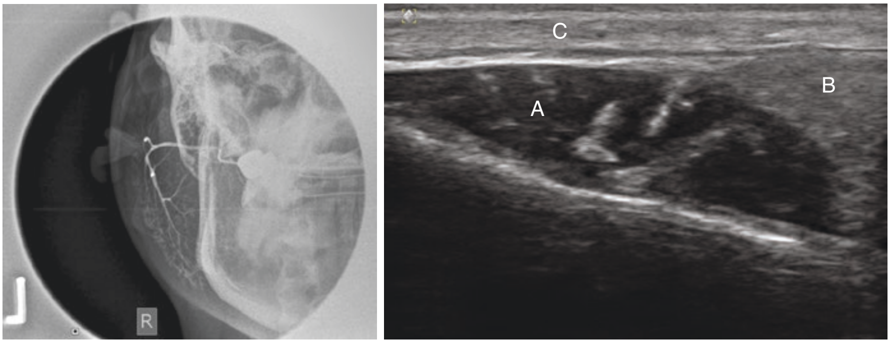

Fig. 5.4 A sialogram of the right-hand side parotid gland (anterior view) performed with Omnipaque® 350 is shown on the left-hand side of a patient with a unilateral facial swelling which was not related to teeth. The swelling of the face and the expansion of the parotid gland can be seen clearly in this image. On the right-hand side the ultrasonography of the right-hand-side masseteric muscle (A) is shown, in the same patient with a unilateral swelling of the face, later diagnosed as mumps. The parotid gland (B) looks normal in the ultrasound image, as does the skin (C)

used in the dental setting, this imaging modality will usually be available in specific hospital settings or private specialty clinics.

Figure 5.4 illustrates the use of ultrasound imaging in a case of a swollen parotid gland in a teenage patient. Dental examination did not indicate a dental cause for the swelling. A sialogram with contrast medium (Omnipaque® 350) was performed to assess the parotid salivary gland. Since the patient also complained of pain in the masseteric muscle, an ultrasonography was made of the masseteric muscle, to rule out a muscular issue or any other pathology that could cause the same symptoms. The swelling was diagnosed as mumps and confirmed with a blood test.

Further Reading

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