Clinical review

New trends in head and neck imaging

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Summary. The development of novel imaging techniques has exerted a larger influence on medical science than have any other advances in the last decade. The following occurrence are now evident in imaging for all medical disciplines: reduced use of ionizing radiation, abandonment of invasive methods, real-time properties, visualization of functional parameters, digitalization and pooling of information, as well as interaction of user with image information. A wide variety of imaging methods is now available clinically for the study of head and neck diseases. However, only picture archiving and communication systems (PACS) can efficiently handle and integrate information coming from multiple imaging modalities, such as computed tomography, magnetic resonance imaging, positron emission tomography, digital subtraction angiography and digital radiography. Such systems also incorporate image workstations that the surgeon can use for preoperative planning and even perioperative assistance. Current PACS are reviewed, since their future use may change the operating theater and also change surgical strategies.

Key words: Medical imaging – Picture Archiving and Communication Systems – Image workstation – Computer-assisted surgery

Introduction

The development of novel imaging techniques has exerted a larger influence on medical science than has any other advance in the last decade. This does not only apply to diagnostic testing in most medical branches but increasingly has involved the field of therapy as well. Because of the variety of methods now available – whether they have been developed de novo or have been further refined from known material – utility in actual practice is often lost. This fundamental concept is often masked by individual circumstances but should be investigated and analyzed more precisely for its importance in head and neck imaging.

Certain tendencies are evident in imaging for all medical disciplines. These involve the reduced use of ionizing radiation, abandonment of invasive methods, real-time properties, visualization of functional parameters, digitalization and pooling of information as well as possible interaction of the user with image information.

Reduced use of ionizing radiation

Not least because of the nuclear power plant disaster in Chernobyl, lay persons have become very much aware of the effects of ionizing radiation. One “side effect” of this disaster has been an ongoing comparison between natural radioactivity, industrially caused radiation including that released from the disastrous reactor and the radioactivity due to radiodiagnostic substances used in medical science.

On the one hand, the heightened sense of awareness in the medical profession has led to an improved documentation of irradiation (as reflected in the “X-ray passport”). On the other hand, this awareness has resulted in an increased application of imaging techniques that dispense with the use of ionizing radiation, e.g. sonography and magnetic resonance imaging (MRI).

During the last 10 years the technique of ultrasound has widely expanded from the domain of in-patient care into the sector of outpatient clinics and private medical/surgical practices. Sonography has proved successful in the diagnosis and management of abdominal diseases, various vascular disorders, arthropathy, cardiac disease as well as in gynecological and urological pathologies. However, in studying head and neck disease abnormalities of the paranasal sinuses and orbits require initial radiological findings. Subsequent sonographic images have then proven helpful for documenting the course of treatment rendered [3, 53]. As a trend in the development of ultrasound techniques, the miniaturization of more differentiated probes has occurred for use in interventional and intraoperative sonography [4] (as later discussed).
Unfortunately, the initial optimism for the complete substitution of roentgenological methods by sonography and MRI within a few years’ time has not been maintained [1, 19]. MRI is still a time-consuming, costly technique. As such, it has been reserved to hospitals commonly used as referral centers and to highly specialized private practices.

Additionally, MRI studies often require completion by computer tomographic (CT) findings [6]. As a result, approximately 70% of all radiological studies to date have been carried out using conventional radiography. Nonetheless, in these cases, the use of digital radiography can lead to a 50% reduction in exposure to radiation without any detrimental effect on diagnostic quality.

Abandonment of invasive methods

As a maxim of clinical diagnostics, a diagnosis should be made using the least possible number of invasive methods. This especially applies when imaging techniques are employed. As in reducing exposure to ionizing radiation, MRI also gains major importance for its replacement of invasive methods in diagnostic testing. In studying the structures of the cranium, surmounting the osseous bar is well known. In this case, as in other regions of the body, differentiated visualization of soft tissue serves as a basis for detailed assessments of possible pathology. In some cases, a biopsy specimen can be avoided by histodifferentiation and tissue characterization in MRI. Tissue characterization is possible with fixed organs using variable pulse sequences. Additionally, differentiation between recurrences of tumors and surgical scars has been described in cases of operated mastocarcinoma by a combination of short and long magnetic echo sequences with multi-echo sequences [63]. However, analysis of these echo sequences requires considerable calculation, which is optimized only by an expert system.

MRI has proven vital in the differential diagnosis of lesions of the petrous bone, cerebellopontine angle tumors and other central nervous system (CNS) diseases [65]. As such, the invasive method of air cisternography for studies of the internal auditory meatus has become superfluous [23]. With the contrast medium gadolium-DTPA, the sensitivity of the method can be increased to almost 100% for even the smallest intrameatal tumours [42, 60]. This latter contrast medium has also been employed successfully for the visualization of jugular glomus tumors or other vascular lesions, allowing MRI to replace the formerly used combination of CT and angiography, simultaneously avoiding radiation exposure and invasive methods. With fast imaging with steady-state precession (FISP) sequences, MRI is now also possible for quasi-angiographic visualization of vessel flow rates.

MRI has a special value for surgical planning through its three-dimensional visualization of moving and fixed organs [13, 15]. Surgical approaches can be optimized when exact information is available on the expansion of pathological processes. Sonography [45] and MRI offer additional advantages for defining the location of an abscess (Fig. 1), allowing drainage to be effected via minimal incisions [41]. Similarly, non-invasive diagnosis of such pathology as encephaloceles is possible [39], obviating the need for surgical exposure of the skull base for definition.

A successful non-invasive routine technique used to examine cardiac action has been color Doppler sonography and has demonstrated function parameters formerly possible only by invasive cardiac catheter studies. This latter study can also be used in angiology to quantify vessel stenoses and replace invasive angiography for defining suspect large vessel obstructions in the head and neck [26, 31]. A more recent alternative for direct non-invasive flow measurements is the novel technique of color velocity imaging (CVI) [49].

High-resolution CT has now become an important tool for reducing invasive diagnostic procedures in patients with head and neck lesions. Such investigations have also proven useful in following temporal bone disease. According to Oberascher et al. [48], it is possible to dispense with the routine “second-look” surgery for cholesteatoma because residua can be reliably detected in high-resolution CT. By so doing, revision surgery can be expedited [67]. After stapedectomy with insertion of a prosthesis, such complications as too long, too short or