MRI for the Dental Practice. A Technology Finds its Way

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Magnetic resonance imaging (MRI) is an indispensable tool in the field of radiology. For decades, our MRI systems have been supporting diagnosis and treatment in clinical fields such as orthopedics, neurology, and oncology, to name just a few.

To date, MRI has played only a marginal role in dentistry. Yet as a non-ionizing imaging modality that provides superior soft tissue contrast, MRI has much to offer this discipline. Onsite access to an MRI system would help dentists fill the diagnostic gap left by their traditional dental imaging systems.

When we started exploring how we could bring MRI into dental practices, it quickly became clear that a dental-dedicated MRI (ddMRI) system would have to fulfil some very specific requirements: From our ethnographic research, we gained a clear picture of the unique operational and infrastructural realities in dental practices. These insights led us to fundamentally rethink MRI and create a system that is tailored precisely to the workflows, personnel, and clinical questions in dentistry. The aim was to enable dentists, their teams, and their patients to benefit from imaging that shows, for instance, whether a nerve is too close to a wisdom tooth, whether pulp is vital, or whether the temporomandibular joint (TMJ) is structurally damaged.

The diagnostic gap

To understand why MRI matters for dentistry, it helps to look at what radiologists have been using routinely for decades. In orthopedics, no cruciate ligament tear is diagnosed without MRI; no herniated disc, no meniscal lesion, no rotator cuff rupture. In neurology, MRI is the gold standard for virtually every question. In oncology, cardiology, gastroenterology — wherever soft tissue contrast is decisive — MRI has become indispensable.

Dentistry, by contrast, still works primarily with ionizing radiation. The orthopantomogram shows bone and teeth in an overview image. Cone beam computed tomography (CBCT) delivers three-dimensional representations with excellent resolution for hard tissues. Both of these modalities are invaluable and firmly established in dental practice. But they share a fundamental limitation: Soft tissue appears largely uniform, with little structural differentiation.

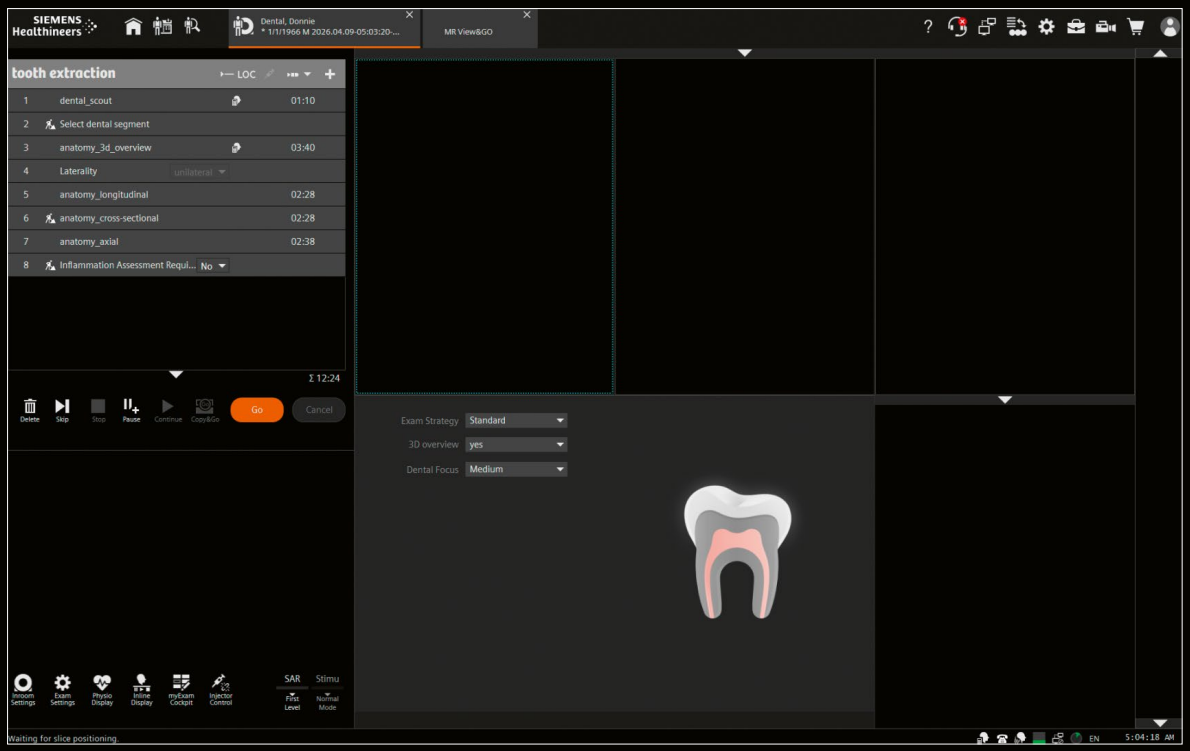
In practical terms, this means that the TMJ articular disc (a cartilaginous structure only a few millimeters thick and a frequent cause of TMJ disorders) is invisible on CBCT. The dental pulp, whose vitality may determine whether a tooth can be preserved, can only be assessed indirectly. The inferior alveolar nerve — which must be protected during implant placement or wisdom tooth extraction — can only be inferred from the surrounding bony canal, not visualized directly.

This diagnostic gap is no secret. Dentists know there are clinical questions for which their available imaging modalities provide no satisfactory answers. Until recently, the solution has been to refer patients to radiology practices or hospitals for MRI examinations in special cases. This is cumbersome, time-consuming, and simply not practical for many clinical questions.

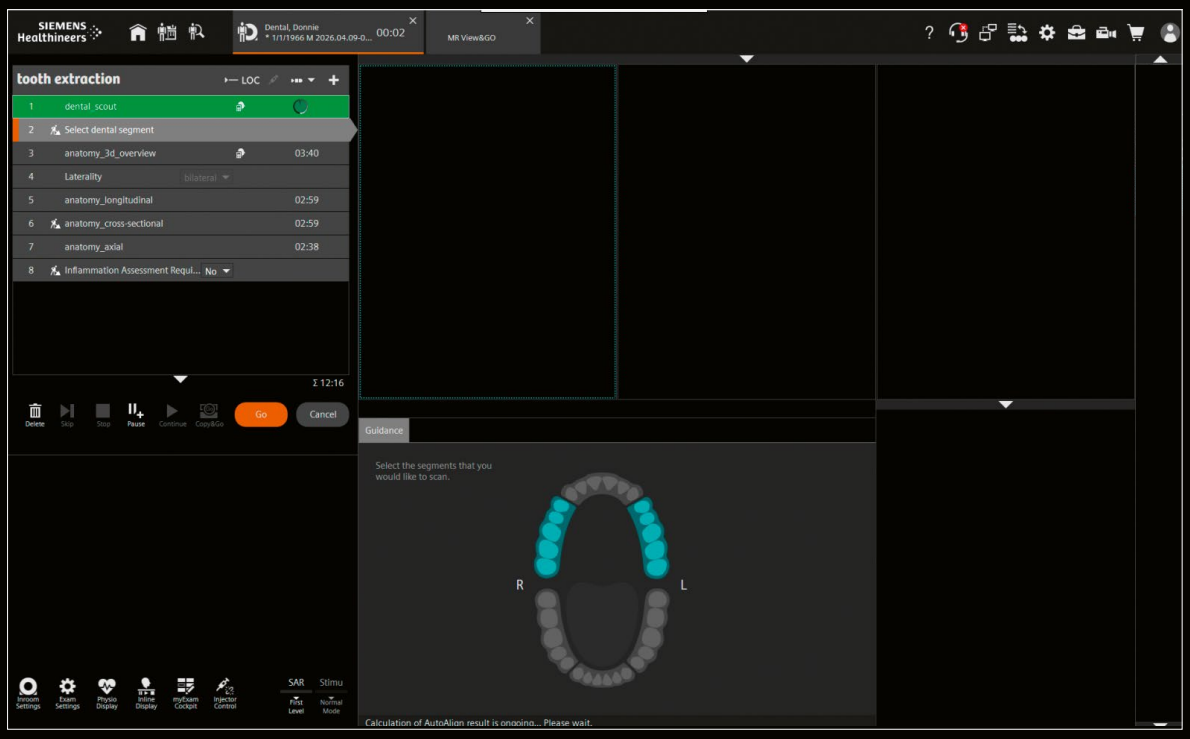
Why a conventional MRI scanner is not the answer

At first glance, the solution might seem obvious: Install a conventional MRI system in the dental practice. In reality, this won't work due to fundamental workflow differences. Conventional MRI systems are designed for operation by specialist personnel, who make decisions about anatomical planes, sequence types, slice thicknesses, repetition and echo times, flip angles, and fat suppression. Each parameter influences image quality and diagnostic value. Radiology technologists spend years becoming experts in these relationships.

Tooth extraction workflow



1 Tooth extraction is the most complex workflow. It requires three primary user interventions (indicated by the operator icon): dental segment selection, fine adjustment of cross-sectional slices, and optional inclusion of additional inflammation sequences.

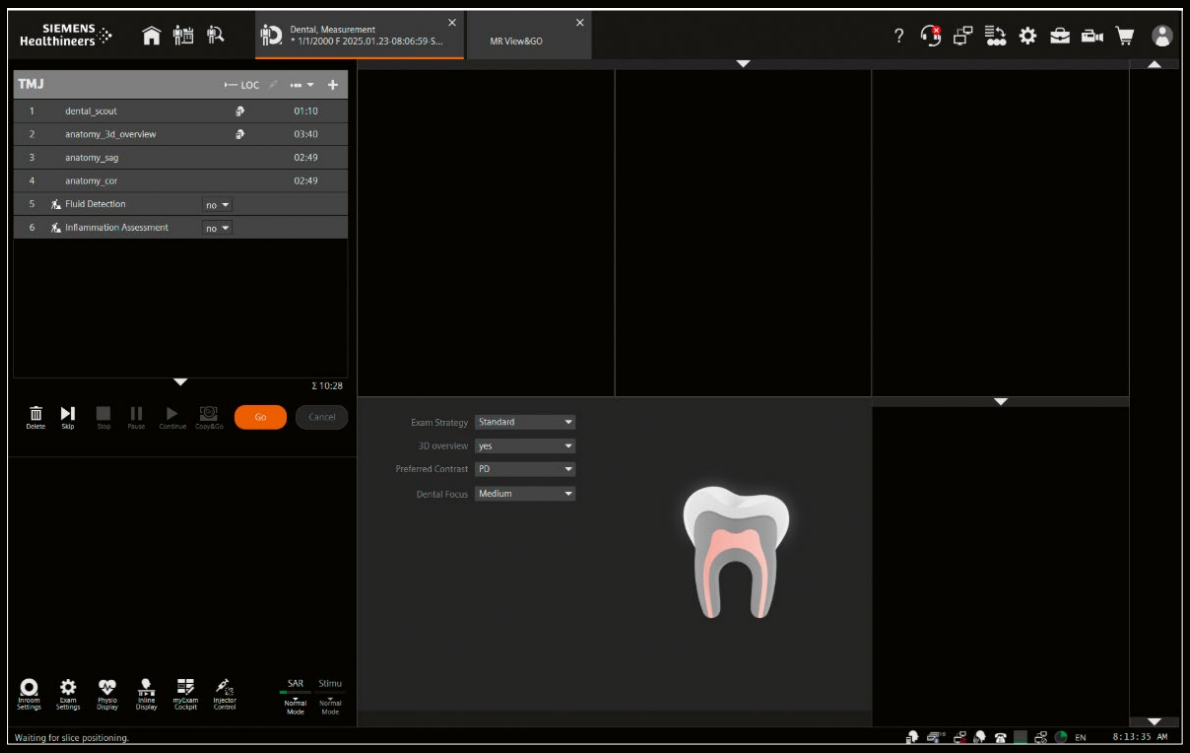


2 The selection of dental segments relevant for the examination follows established cone beam CT workflows. This supports intuitive use and easy recognition for users familiar with CBCT.

3 The only interactive planning step occurs on the cross-sectional images. This is to achieve correct tooth selection and adequate coverage of the root or area of interest while minimizing acquisition time. The user is guided through this process.

4 If inflammation is suspected, the user can extend the workflow with additional steps, which are automatically planned in advance.

TMJ workflow



5 The TMJ workflow is fully automated. User interaction is only required if additional contrast acquisitions for fluid detection or inflammation assessment are required.

Dental practices do not have this workforce — and maintaining one would make no economic sense. A dental assistant who provides chairside assistance, schedules appointments, and takes X-rays cannot be expected to also become an MRI specialist on the side. Dental practices therefore need an MRI system that non-specialist staff can operate without compromising image quality or outcomes.

Spatial and infrastructural constraints are another issue. Conventional MRI systems require large rooms, elaborate shielding, a helium supply with quench pipes, and reinforced floors to take the magnet's weight. Most dental practices lack both the space and the financial means to make such modifications.

From observation to solution

The development of our ddMRI system — MAGNETOM Free.Max Dental Edition — began not with technical specifications, but with ethnographic field research. We shadowed dentists, analyzed workflows, and spoke extensively with practitioners. We learned that a 45-minute MRI exam is incompatible with 15-minute appointment slots; that complex planning steps will not survive daily practice; that dentists think in tooth regions and jaw segments, not coronal and sagittal planes; that they care exclusively about the dentomaxillofacial region; and that technical terminology creates unnecessary barriers.

From these insights, clear design principles emerged: Examinations should be indication-driven, not parameter-driven. Instead of selecting sequences, users choose clinical questions or anatomical targets. For each indication — whether TMJ diagnostics, nerve visualization, pulp assessment, or periodontal evaluation — the system automatically configures all technical settings. The myExam Dental Assist software guides the user through every step, from patient positioning to the finished scan. In routine cases, the full examination can be completed in less than 15 minutes.

Patient positioning is handled via Select&GO with automatic isocentering. This is performed at the touch of a button instead of via manual adjustments. The Dental Segment Planning Add-In extends automation to tooth-

specific imaging: Clinicians simply select the relevant dental segment, then the system identifies the anatomy, plans slice groups, and sets imaging geometry automatically using AutoAlign. Cross-sectional planes can be fine-tuned for precise local imaging, with support from dedicated guidance tools. The system enables TMJ examinations to be planned fully automatically.

Imaging quality is supported by Deep Resolve, an AI-based reconstruction technology that achieves 0.3-millimeter in-plane resolution with substantially reduced scan times. Examination programs carry descriptive dental names rather than technical sequence labels, bridging the language gap between MRI technology and dental practice.

We also had to rethink the hardware. The standard head coils used in radiology are optimized for broad anatomical coverage — from the vertex to the base of the neck. For dental imaging, they are too large, difficult to position, and unsuitable for dedicated dentomaxillofacial imaging. The newly developed 7-channel dental coil features an open architecture for patient comfort and access. It can be secured with one hand and is adjustable in the tilt angle and longitudinal direction. Reproducible alignment is facilitated by integrated positioning markers at the glabella and orbits. The dental coil also enables the use of established dental positioning aids, such as bite wedges. The scanner's 80-centimetre bore diameter, open coil design, and dedicated cushioning system substantially improve patient comfort, which is particularly relevant for claustrophobic patients.

Seeing more

Achieving clinically useful image quality within dental time constraints relies on advanced reconstruction technology. Deep Resolve is a deep-learning-based algorithm trained on high-quality MRI datasets to recover spatial resolution and reduce noise from undersampled acquisitions.

Traditional MRI balances resolution, signal-to-noise ratio, and acquisition time. High-resolution imaging usually means long scans or noisy images. Deep Resolve relaxes this trade-off by reconstructing high-quality images from less data. The result is up to 60% shorter scan times, while maintaining 0.3-millimeter in-plane resolution.

This resolution is enough for visualizing structures that are critical to dental diagnosis: the pulp chambers, root canals, alveolar cortex, and the TMJ disc. While CBCT still surpasses MRI for pure bone morphology, ddMRI offers a different diagnostic value: Its strength lies in its ability to visualize soft tissue contrast, inflammation, vascularization, and pulp vitality. This is often more decisive than incremental gains in geometric resolution.

Optimized soft tissue contrast enables clear differentiation of the pulp-dentin interface, inferior alveolar and lingual nerves, and soft tissue components of the TMJ. These capabilities fundamentally exceed what radiographic techniques can provide, and they complement CBCT rather than replace it.

Focusing on what matters

A unique challenge in dental MRI is clinical focus. Dentists are experts in dentomaxillofacial anatomy. Intracranial structures are usually irrelevant and introduce distraction rather than clarity.

The Dental Focus addresses this through acquisition-level field-of-view restriction. Three calibrated modes (narrow, medium, wide) ensure that only clinically relevant anatomy is displayed at diagnostic quality. The result is focused, unambiguous imaging tailored to dental decision-making.

We also adapted the orientations and the nomenclature of MRI. Instead of coronal and sagittal views, images are presented using dental orientations: longitudinal, cross sectional, and axial views aligned to the teeth and jaws. AutoAlign algorithms based on cephalometric landmarks provide consistent orientation. The system is capable of producing three-dimensional panoramic reconstructions, longitudinal sections aligned with the dental arch, and cross-sectional views perpendicular to specific teeth.

An MRI system that fits into dental practices

The MAGNETOM Free.Max platform removes infrastructural barriers. It operates with only 0.7 liters of helium, which is sealed in a maintenance-free system that requires no refilling and no quench pipe. Space requirements are under 25 square meters. At less than 3.2 tons and under two meters in height, the system also fits through standard doors. Siting complexity is therefore dramatically reduced compared to high-field MRI systems.

The diagnostic scope of dental-dedicated MRI

Clinical applications span multiple domains of oral and maxillofacial medicine. In TMJ disorders, MRI is the only non-invasive modality that directly visualizes the articular disc, showing its position, shape, and integrity. Differentiating between muscular dysfunction, disc displacement with or without reduction, and degenerative joint disease is clinically decisive and fundamentally influences the therapeutic approach.

In endodontics, MRI enables direct visualization of the pulp. Current vitality tests — thermal or electrical — provide indirect, sometimes ambiguous information. MRI can display inflammatory changes around the apex,

enable assessments of vascularization, and support the detection of periapical pathology at early stages before substantial bone loss has occurred.

Periodontics benefits from visualization of soft tissue inflammation and ligament integrity. Active periodontitis shows characteristic edema and hyperemia on MRI before radiographically detectable bone loss occurs. The extent of soft tissue attachment loss can be assessed non-invasively, complementing clinical probing.

MRI makes surgical planning more precise, thanks to the detailed nerve visualization. The inferior alveolar nerve, mental nerve, and lingual nerve can be traced along their courses. This allows more precise planning of implant placement, wisdom tooth extractions, and orthognathic procedures, particularly in cases where the nerve course is unusually close to the planned surgical site or where previous interventions have altered normal anatomy.

In juvenile dentistry, the absence of ionizing radiation is particularly relevant. Repeated MRI in growing children — to monitor dental development, assess impacted teeth, or follow trauma over time — carries no cumulative radiation burden.

Beyond these applications, the technology opens up possibilities for clinical questions that have traditionally been difficult to address. Osseous lesions with predominantly medullary involvement can be detected earlier by MRI than by CT. Soft tissue tumors and cystic lesions can be differentiated more confidently. Osteonecrosis of the jaw — whether medication-related or from other causes — shows characteristic marrow signal changes on MRI before radiographically visible bone destruction occurs.

A system tailored to the practical realities of dentistry

With ddMRI, magnetic resonance imaging enters dentistry not as a tool simply transplanted from radiology, but as a system designed for the realities of dentistry.

What makes this transition viable is not mere miniaturization or cost reduction, but rather comprehensive adaptation. The ddMRI system works because it respects the constraints of dental practice: limited time per patient, operation by personnel without specialist training, integration with existing imaging modalities, and strict adherence to scope-of-practice boundaries. It delivers genuine diagnostic value — soft tissue visualization that cannot be obtained by other means — while fitting into established workflows.

Dentists gain access to a diagnostic modality that was previously out of reach. Patients benefit from improved diagnostics without referrals or radiation exposure. The technology makes visible what has long been invisible.

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