ROLE OF FAT SUPPRESSION SEQUENCES IN INFLAMMATORY DISEASES

A Systematic Review

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ABSTRACT

Objective: The aim of this study is to review and generate a current state of knowledge regarding the use of fat suppression sequences in the evaluation of inflammatory diseases. The primary emphasis is on the critical roles of fat suppression sequences for enhancing the visibility and variations of inflammatory lesions by suppressing the signal from adipose tissue, which can frequently disguise or mimic pathological changes.

Materials and Methods: A literature search was conducted using PubMed, Springer, Google Scholar, Elsevier, and The Asian Spine Journal. Data was collected from all of the research studies mentioned in this analysis.

Results: According to the information provided, ten of the twenty articles appear to have used the Dixon sequence to identify various inflammatory diseases. Furthermore, compared to other diagnostic modalities, the Dixon sequence appears to be a more effective way to assess inflammatory diseases, according to the results of these articles.

Conclusion: The Dixon sequence is a reliable and effective method for identifying a range of inflammatory diseases, according to the data presented, which provides substantial information in support of this assertion. Dixon sequencing offers a promising alternative for medical imaging due to its benefits, which include a decreased reliance on high signal-to-noise ratios (SNR), high field strengths, and low specific absorption rates. Its robustness and applicability in clinical settings are also further enhanced by its capacity to reduce sensitivity to metal artefacts and magnetic field inhomogeneity.

KEY WORDS: Dixon, STIR, SPAIR, Fat-Saturation

INTRODUCTION

Magnetic resonance imaging (MRI) is a non-invasive clinical imaging examination that generate comprehensive images of tissues within the body such as organs, muscles, bones, and vessels of blood. It creates images of the body through the use of magnets and radio wavelengths. [1]

- MRI used to investigate or diagnose conditions affecting soft tissue, such as:
- Tumors, including cancer
- Injury or disease of the joints
- Injury or disease of the spine
- Soft tissue injuries such as damaged ligaments [2]

FAT SUPPRESSION

MRI fat suppression sequences are commonly used to suppress fat signals or detect adipose tissue.[4] Hydrogen proton counts in adipose tissue show high signals in both T1-weighted (T1W1) and T2-weighted (T2W1) images, covering signals from other tissues as well as creating chemical shift artifacts. Fat suppression sequences can suppress signals from adipose tissue and can therefore be used to improve visualization of contrast uptake in routine MRI. [3]

For achieving fat suppression there are several technique:

- FS: Frequency selective fat saturation
- STIR: Short tau inversion recovery
- Water excitation, in phase/opposed phase imaging
- SPAIR: Spectral attenuated inversion recovery fat suppression
- Dixon method
- Each has particular clinical applications, limitations, advantages, and disadvantages. [4]

Frequency – Selective Saturation (FS)

A frequency-selective saturating RF pulse with the same resonance frequency as the lipid is delivered first, subsequently followed by a gradient pulse to disrupt the homogeneity. As a result, the signal we acquire does not include the contribution of lipids. Used for all MRI sequences: T1WI, T2WI, and PDWI (FS-T1WI, FS-T2WI, and FS-PDWI). [3]

Short- TI Inversion Recovery (STIR)

On the basis of variations in the TI of the tissues, it can suppress the fat signal. The TI of water is lower than that of fat tissue. The longitudinal magnetization of fat tissue will recover more rapidly than that of water following a 180 degree inversion pulse. The signal produced by water without fat tissue can be acquired by applying a 90-degree pulse at the fat tissue null point. Low-field-strength magnets can use STIR because it is unaffected by magnetic field inhomogeneity. Additionally, it can be used for large FOV scanning of the spine, long bones of the limbs, and the trunk. [3]

Frequency Selective Inversion Pulse (Spectral pre-saturation with Inversion Recovery SPIR, Spectral Pre-saturation Attenuated Inversion Recovery SPAIR)

On the basis of short TI and adipose tissue resonant frequencies, it can be viewed as a combination of fat saturation and Short tau inversion recovery. The SPIR method includes 100-140 inverted pulses before returning the actual pulses. SPIR shortens the scan time in order to reduce the angle of an inversion pulse. The criteria for magnetic field uniformity are high. A 180-degree inversion pulse is first used in the SPAIR method to completely saturate the adipose tissue. When the rotation angle is greater than the SPIR, the scan time and SAR value increases as well. [3]

DIXON METHOD

Dixon techniques were developed in 1984 and have been evolving since then. Software (algorithms for reliable fat-water separation) and hardware advancements (better gradient systems, post processing power) have enabled their use in the clinical setting. It takes advantage of the fact that the resonance frequencies of protons in water and fat are offset, causing tissues to be out of phase with each other on a regular basis (approximately every 2.4ms at 1.5T and every 1.1ms at 3T). This is known as a chemical shift. The basic idea behind these techniques is that each voxel encodes the signal at a fixed offset during acquisition and then estimates the contribution of fat and water protons to the measured signal during post processing. It can be used in gradient echo and spin-echo sequences, with some technical modifications using either multi repetition or multi Echo methods. [5]

METHOD and MATERIAL

A literature search was conducted to identify studies examining the use of the fat suppression sequence in MR imaging of various inflammatory diseases. Titles, abstracts, and articles with both prospective and retrospective data and other studies were used. All the articles were taken from Google Scholar, PubMed, Springer, Elsevier, and the Asian Spine Journal. Additional references were identified through searches of the bibliographies of the full-text papers retrieved.

All information has been obtained from the article abstracts, full-texts, and their supplementary data when applicable. The data required is from patients with different indications of inflammatory diseases. Finally, a total of 20 original articles have been identified and included in the review. The study results are tabulated, but meta-analysis is not performed due to the heterogeneity of study designs, study populations, and outcome measures reported.

Inclusion criteria

- Only papers published in the year 2010 or after.
- Patients of all age groups.

Exclusion criteria

- The publication written in any language that is other than English.

Table 1: Presentation of mentioned 20 articles

	Author	**Year**	**Study Sequences**	**Main findings assessed**

1	Alexander M McKinney	2012	Fat suppressed contrast enhanced T1-weighted	Highest sensitivity in detecting acute optic neuritis
2	Sangmin Lee	2018	T2 –weighted two-point Dixon compared with SPAIR	T2 Dixon show better delineation of spine lesions
3	Hye Na Jung	2016	Fat suppressed T1-weighted and T2-weighted	Useful to differentiate between nasopharyngeal inflammatory & nasopharyngeal carcinoma
4	T. Kirchgesner	2017	3D T1-weighted Dixon compared with CHESS	Dixon method more effective in hands of patients with inflammatory disorders
5	Lu Chen	2020	Two-point Dixon T2-weighted compared with Conventional fat saturation	Dixon improved sensitivity and specificity in staging thyroid-associated ophthalmopathy
6	Willemijn H.F.Huijgen	2019	T2-SPAIR FSE compared with mDixon FSE	mDixon is preferred in tumor protocols
7	Wakako Kaneko Mikami	2013	Two-point Dixon compared with frequency selective inversion method	Two-point Dixon improved the contrast & visibility of the enhanced breast lesion & axillary lymph nodes
8	Thomas Kirchgesner	2021	Contrast-enhanced T1-weighted Dixon water-and fat-only	Assessment of osteitis and erosions

9	S. Brandao	2013	T1-weighted &T2-weighted three-point Dixon compared with T1-weighted fat saturation and STIR	T1W and T2W Dixon showed lesion conspicuity accurate for clinical diagnosis
10	Niels van Vucht	2019	Dixon technique	Useful for characterizing bone lesions
11	Henri Guerini,MD	2015	Dixon technique	For better delineation of tumor extension
12	Mohammed Azfar Siddiqui	2017	STIR or fat suppressed T2W fast spin echo	Suggestive for Tubercular spondylitis
13	Mi Sun Chung	2014	T2W MRI comparison with and without fat suppression	Fat suppressed T2W differentiating angiomyolipomas from non-angiomyolipomas
14	Vitor Faeda Dalto	2017	SPAIR T2W technique compared with STIR	SPAIR T2W evaluate sacroiliac joints subchondral bone marrow oedema
15	Sunghoon Park	2016	Fat suppressed T2 weighted	Highly specific for diagnosis of adhesive capsulitis
16	Osama Al-Saeed	2011	Gadolinium enhanced Fat saturation T1W	Improved conspicuity of lesions in patient with multiple sclerosis

17	Ercan Inci	2010	Fat suppressed contrast enhanced T1W	Most useful imaging tool for diagnose acute appendicitis
18	Shigeaki Suenaga	2016	Fat saturated T2W and dynamic fat suppressed	Detect synovial inflammatory process in TMJ
19	Fatma Nur Boy	2014	Fat saturated T2W or STIR	Accurately demonstrate osteitis
20	Jing Wu	2012	Fat suppression sequences	Diagnosis of bone joint diseases

RESULT

A total of 20 studies were identified that met the inclusion criteria. Out of all the studies, ten (n=10/20; 50%) studies used Dixon sequences among which three (n=3/20; 15%) studies reviewed the clinical use of only Dixon sequences in various inflammatory diseases; six (n=6/20; 30%) studies compared Dixon techniques with other fat suppression techniques such as Frequency-selective inversion sequence(FS), CHESS sequence, T1-weighted fat-saturation & STIR ,Conventional fat-sat and SPAIR sequence; one (n=1/20; 5%) study uses Dixon technique with fat suppression in musculoskeletal imaging; in remaining ten studies, six (n=6/20; 30%) studies uses fat suppression T1-weighted , fat suppression T2-weighted or STIR ; three(n=3/20; 15%) studies uses fat saturated T1- weighted and T2-weighted or STIR; one (n=1/20; 5%) study uses SPAIR T2 fat saturation technique alternative to STIR sequence.

DISCUSSION

This study evaluates the role of fat suppression sequences in various inflammatory diseases. There are three types of fat suppression techniques:

1) Inversion based fat suppression (STIR)
2) Chemical shift-based fat suppression [Chemical shift selective (CHESS)]
3) Water excitation and Dixon],
4) Hybrid techniques (Spectral attenuated inversion recovery (SPAIR) and Spectral pre-saturation with inversion recovery]. (6)

Dixon was the most frequently studied technique in this study. Chemical shift imaging (CSI) algorithms and Dixon type pulse sequences are now frequently employed as a conventional fat suppression technique. The Dixon technique can be employed with spin echo and gradient echo sequences for two-dimensional, single-slice, or three-dimensional parallel imaging. [7]

Dixon technique is based on a combined collection of in-phase and out-of-phase images, subsequently completing an estimation of water only and fat only. [8] It is an alternative method for fat suppression that collects multiple echoes with different relative phases between the protons of water and fat. The Dixon method can be categorized as single-point, two-point, three-point, or multi-point, as in three or more, based on the quantity of acquired echoes. [9] It decreased the need for high SNR, strong fields, and low specific absorption rates, sensitivity to artefacts made of metal, and insensitivity to magnetic field inhomogeneity. [10]

CONCLUSION

When compared to other methods of fat suppression, Dixon techniques offer many advantages. Dixon sequencing is an important imaging technique in the field of medical diagnosis because of its advantages, including its ability to reduce the dependence on high signal-to-noise ratio (SNR), high field strength, and low specific absorption rate (SAR), as well as its reduced sensitivity to metal artefacts and insensitivity to magnetic field inhomogeneity. Dixon sequencing may make diagnostic imaging more accessible to a wider range of patients by reducing the need for expensive and resource-intensive equipment. This could ultimately result in better patient outcomes and possibly lower healthcare costs by enabling earlier detection and intervention in inflammatory diseases.

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