# Segmented multi-slice (SMS) acquisition for minimum z-FOV axial continuously moving table MRI

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## INTRODUCTION

Axial continuously moving table (or move during scan, MDS) MRI is highly promising for the acquisition of any extended FOV within a minimum scan range along the scanners z-axis [1-2]. Consecutively slice acquisitions use a limited scan range of one or two times the slice thickness for data acquisition. Therefore, maximum homogeneity in image intensity and contrast can be achieved in plane and through plane using the isocentre of the magnet for scanning. Interleaved multislice acquisition techniques, on the other hand, expand the scan range to two times the extension of the multislice package [3]. Any deviation in gradient linearity or coil sensitivity along this scan range leads to data inconsistency in the axial images as well as to varying image properties along the slice axis. Segmented multislice (SMS) acquisition is a new technique for axial moving table acquisitions that permits the reduction of the scan range for multislice sequences. It's based on the idea, that only parts of the k-space are acquired at different scanner positions. The full k-space data set of any anatomical slice is collected while the slice moves through the scanner from one scan position to the next. This leads to a reordering scheme in the patient coordinate system that was previously published for multislice TOF imaging [4].

## METHODS

In conventional MDS multislice acquisitions each of N scan positions follow one anatomical slice for the duration of the slice acquisition (Fig.1, top). After each measurement the scan positions are reset. Repeated measurements acquire "vertical" slice packages in the patient that are concatenated along z, opposite to the table motion. Neighboring anatomical slices at the stitching points are acquired in the scanner at opposite ends of the scan range. The scan positions for each slice change over the range the table moves during the measurement. For the new SMS acquisition k-space is divided into N segments (different grey scales in Fig.1 bottom). Each k-space segment is allocated to a different scanner position. While any anatomical slice of the patient moves through the scanner, different k-space parts are acquired at the different scanner positions. During the acquisition of a single segment the scan positions follow the table motion for one slice distance. Afterwards the scan positions are reset to acquire the same k-space parts of the newly incoming anatomical slices. Identical k-space lines are acquired at the same scanner position for all slices of the extended FOV. The scanner positions for k-space lines of different segments are distributed over the thickness of the slice package along z. Measurements were performed on a 1.5T Siemens Avanto system during continuous table motion. Local array coils were fixed to the measured object. The implemented sequence was based on a spoiled FLASH sequence, acquiring 16 slices within a TR of 85ms and a slice package thickness of 96mm.. With 160 acquired k-space lines per image a table speed of 7mm/s was chosen for gapless acquisition of the concatenated slice packages.

## RESULTS

Conventionally (a) and with SMS (b) acquired images are compared in Fig.2 and show a coronal reformation of the stack of axially acquired slices. Three types of discontinuities along z can be identified in the conventional scan: 1. The slice acquired first within TR is somewhat brighter in each measurement due to reduced cross-talk effects in these slices. 2. At the stitching points of different measurements, the images show different distortions in the outer parts of the in-plane FOV. A drop of gradient strength in the corresponding scan region causes a locally enlarged FOV and therefore reduced average signal intensity. 3. In regions of maximum gradient field related distortions the images also show an increased blurring (black arrow). In these regions the distribution of the encoding steps along z leads to increased in-plane artifacts than (over the same distance) in more homogeneous areas. In the SMS-MDS images none of the above discontinuities along z are observed and all slices appear as if acquired at the same scanner position. Different scan properties at different scanner positions are exclusively encoded along the phase encoding direction of each image. With the scan positions distributed around the isocentre of the magnet, the trade-off in image sharpness is comparable to that of the conventionally acquired slice of the slice package with the smallest loss in sharpness.
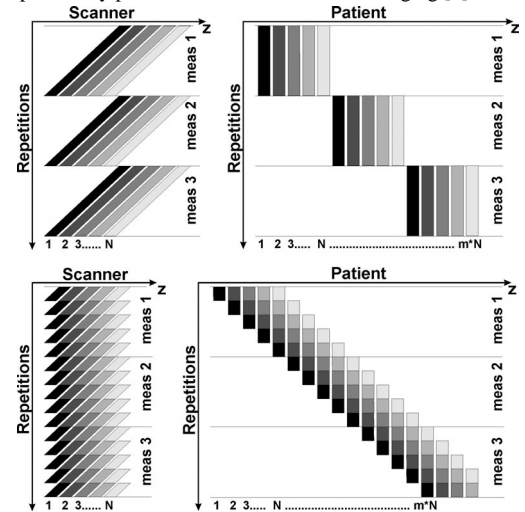


Fig.1: conventional (top) and SMS (bottom) multi slice MDS acquisition in the scanner (left) and the patient (right) coordinate system. Each slice bar represents the total number of k-space lines to reconstruct one image. The grey scale indicates the relative scan positions of the k-space data in the scanner. The table moves towards negative z.

## DISCUSSION

SMS acquisition reduces the scanners range needed in axial multislice acquisitions with continuous table movement to a minimum. Positioning this scan range around the isocentre of the magnet minimizes in-plane artifacts due to inhomogeneities in the gradient linearitiy, $B_0$ or $B_1$ field or coil sensitivity for all slices. Conversely, only one or few slices can be recorded within the same scan range in conventional MDS multislice acquisitions and further slices show increased loss in image sharpness. Any discontinuities between the images along the z-axis are avoided in SMS-MDS acquisitions. This through-plane homogeneity reflects the symmetry of the acquisition: All z-dependent scan properties are encoded identically for all slices of the extended FOV. Conversely, in conventional multislice acquisitions z-dependent scan properties can be observed repeatedly along the z-axis in each measurement. Compared to conventional scans SMS acquisitions suffer from a slight loss in scan efficiency due to incompletely acquired datasets at the beginning and at the end of the extended FOV. However, the relative loss in scan efficiency is small, if the extended FOV is large compared to the thickness of the single slice package, which is typical in applications of this technique.

## REFERENCES

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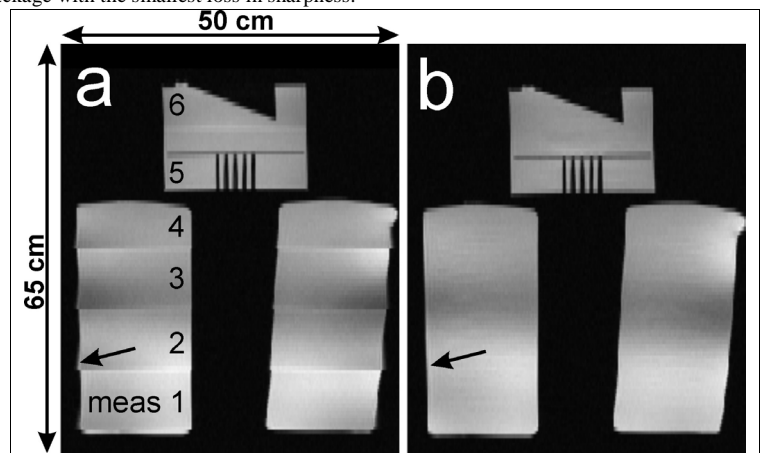[4] Fautz HP, et al. *MRM* **2002** ; 48 :745-752

Fig. 2: Coronal reformation of axially acquired slices using conventional multislice (a) and SMS (b) acquisition. The total phantom is covered with 6 multislice measurements applying a table speed of 7mm/s.