Assuming the motion parameters for the new head position is rotation A around *ISO center* followed by translation s, where A and sa are the parameters required to bring the object back to alignment with the reference image (as in AFNI) and sa is shift AFTER rotation. Then k’=Ak; and the k-space data should be corrected as d’ = d\*exp(-i\*(k’)T\*sa).

On the other, if the shift sb happens before the rotation, then A\*x+sa = A(x+sb), sa = A\*sb. The k-space data should be corrected as d’ = d\*exp(-i\*(k)T\*sb) = d\*exp(-i\*(k)T\*A-1sa) = d\*exp(-i\*(k’)Tsa). The last equation is true since AT=A-1. Therefore, whether use sa or sb give the same result, as long as correct k (or k’) is used.

Assuming the field of view is shifted by s0, we have D = d\*exp(i\*(k)T\*s0). The above correction is equivalent to D’ ≡d’\*exp(i\*(k)T\*s0)=D\*exp(-i\*(k’)T\*sa) at k-space location k’. Since the relationship between k’ and k is random, the reconstruction based on k’ and D’ would produce noisy images.

To avoid the problem, change FOV back to isocenter. Then d=D\*exp(-i\*(k)T\*s0), and d’ = D\*exp(-i\*(k)T\*s0)\* exp(-i\*(k’)T\*sa). Then reconstruct with k’ vs d’. If one wants to shift the FOV back to s0, D’’ = d’\*exp(i\*(k’)T\*s0)= D\*exp(-i\*(k-k’)T\*s0)\* exp(-i\*(k’)T\*sa) = D\*exp(-i\*(k’)T((A-I)\*s0+sa)), then reconstruct D’’ vs k’.

Another approach is to calculate the rotation parameters for rotation around s0. Denoting the coordinates in the old and new frames as x and x’, respectively, then x = x’+s0. y=A\*x+sa = A\*(x’+s0) + sa = A\*x’ + A\*s0+sa. y’ = y-s0 = A\*x’+(A-1)s0+sa. Therefore, in the new frame, the shift became (A-1)\*s0+sa, same as above.

0.9998 -0.0075 -0.0197 -0.0984

0.0073 0.9999 -0.0108 0.3509

0.0197 0.0107 0.9997 0.2993

Shift the image up by 4 mm (2 vox), the the last colume should become a(:,1:3)\*[0,0,-4]'+a(:,4) =

-0.0197

0.3941

-3.6997