

Validation of Upright_Supine Methods Part I: Measurements from Videotapes

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A. Introduction

The purpose of this series of experiments is to validate the methods used in the collection of data for the Upright-Supine study. In the Upright_Supine study, ultrasound data is collected from subjects while they are seated upright and while they are lying supine. The concern is that when subjects are in a supine position, their head in the collar may rotate or translate with respect to the ultrasound transducer.

B. Experiment 1

1. Methods

Two subjects (MAE and MLS) were used in this part. On the ultrasound transducer, three points were marked with cross-hairs, approximately one centimeter apart. To ascertain the position of the head, subjects held between their teeth a tongue depressor that had a large binder clip attached to it. The binder clip was also marked with two colored paper clips. See figure 1. Subjects were recorded on video in upright and supine position while seated in a dental chair. The camera was moved and camera angles were adjusted between the upright and supine recordings. Subject MLS was recorded twice in supine position, the second time keeping her head flat against the head rest. JPEG images were captured from the video using Video Savant.

2. Analysis

Data were analyzed using Scion Image. Four points were selected on the ultrasound transducer (the centers of the three cross-hairs and the corner of the transducer label) and three points were selected on the binder clip (three corners). See figure 2. The corner of the transducer label was not visible in upright position, so it was not used in further analysis. The angles 6,7,2 and 1,3,7 were selected for measurement. The distances 6-1 and 7-1 were also selected for measurement, these were normalized against the distance 1-2.

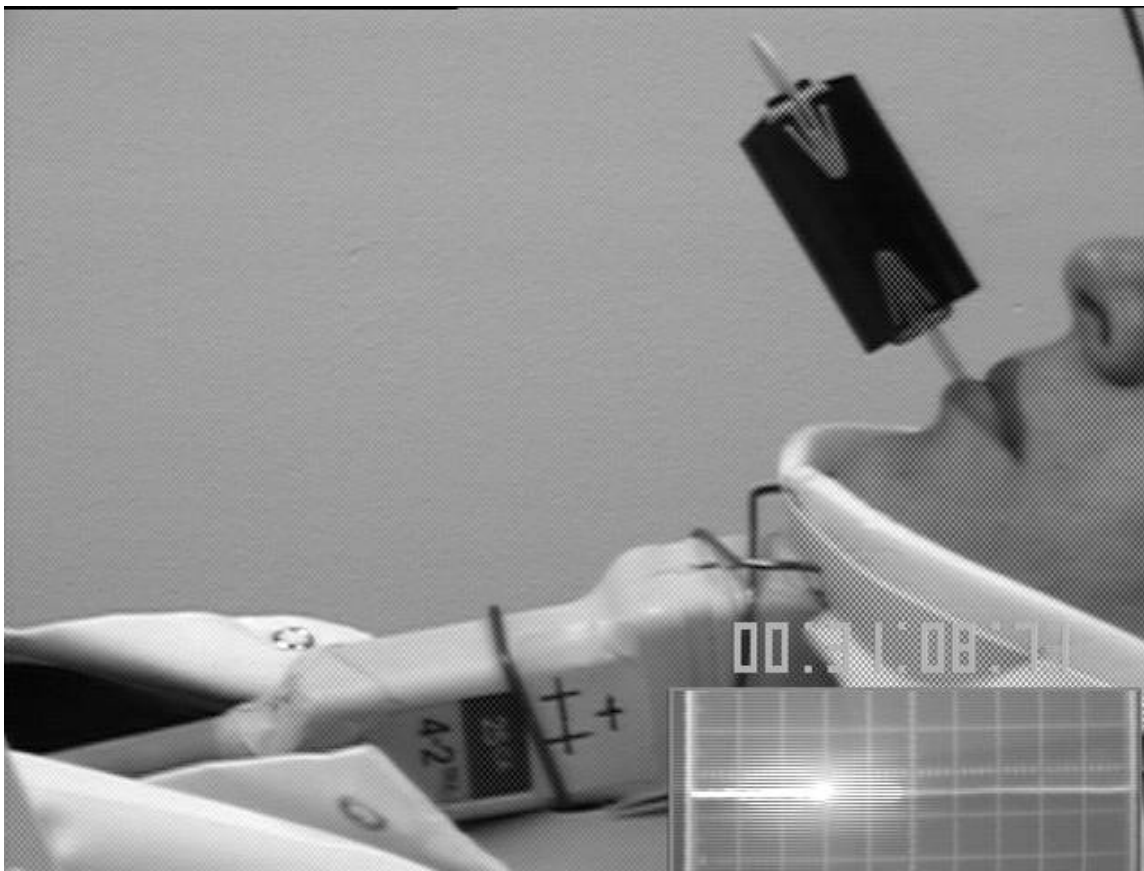


Figure 1. Subject in supine position.

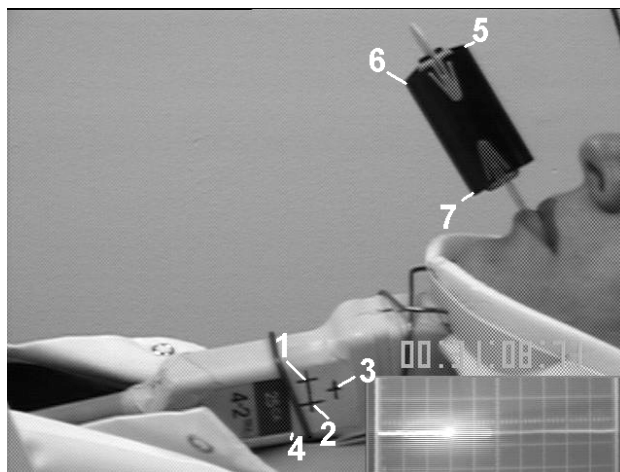


Figure 2. Points used in data analysis.

3. Results

Angles

As can be seen from the results given in table 1, subject MAE did not have consistent angle measurements between upright and supine position, particularly for angle 1,3,7. Subject MLS was also inconsistent for angle 1,3,7; but she did show a very small difference between supine2 and upright for angle 6,7,2.

Table 1. Angle measurements.

Angle in degrees:	6,7,2	1,3,7
MAE_SUP	110.87	105.00
MAE_UP	106.27	96.26
MLS_SUP1	111.33	102.34
MLS_SUP2	108.85	103.87
MLS_UP	108.79	97.00

Distances

As can be seen from the results given below, once again subject MAE did not have consistent measurements between upright and supine positions. Subject MLS, however, was again relatively consistent between supine2 and upright. She was considerably less consistent between supine1 and upright.

Table 2. Distance measurements.

Distance:	6-1 pixels	6-1 calibrated	7-1 pixels	7-1 calibrated	1-2 pixels
MAE_SUP	317.5	14.97	253.46	11.95	21.21
MAE_UP	322.53	10.28	254.08	8.10	31.38
MLS_SUP1	232.13	12.59	192.77	10.45	18.44
MLS_SUP2	230.42	11.30	180.41	8.84	20.40
MLS_UP	222.28	10.90	175.89	8.62	20.40

4. Discussion

There are a number of problems with the study, aside from the numerical results. They are as follows:

- Are the differences in measurements greater than those caused by potential measurement error?
- Are the measurements affected by the change in camera angle/position?
- Are the measurements affected by the change in position? Since these are 2-dimensional images of an object in three dimensional space, angles and relative distances may change in two dimensions in order to maintain perspective.

As a result, a second experiment was conducted using known shapes and distances.

Experiment 1

1. Methods

A 3 in. x 3 in. post-it note was mounted on a 9 in. x 12 in. piece of construction paper. The construction paper was then affixed to a metal arm that was attached to the head of the dental chair. See figure 3. The camera was positioned so that it could record both the upright and supine positions of the dental chair from the same distance and angle. JPEG images were captured from the video using Video Sevant.



Figure 3. Paper mounted onto dental chair.

2. Analysis

Data were again analyzed using Scion Image. One side of the post-it was labeled as “left” and another side was labeled as “top” (see figure 3). The angle between left and top was measured. This angle is known to be 90 degrees. The length of the top and left sides was measured in pixels and the ratio between left and top was calculated. This ratio is known to be 1.00.

3. Results

Angles

In supine position the angle measured 90.38 degrees; in upright position the angle measured 74.22 degrees. Clearly, angle measurements do change between upright and supine positions, even if there is no actual change in the angle.

Distance

In the supine position the ratio was 1.04; in upright position the ratio was 1.06. In other words, the distance ratio does not change between upright and supine position.

4. Discussion

As can be seen from the results above, the angle measurements were not consistent between upright and supine position. Distance measurements, were, on the other hand, and should be used in further validation studies.

C. Suggestions for further research

- Validation must be made using either calibrated distances or distance ratios.
- The camera needs to be positioned in such a way that neither its position nor its angle will be changed between upright and supine recordings.
- Subjects seem less likely to rotate their heads if the back of their head is against the headrest. Ways to encourage subjects to do so need to be further investigated.
- An alternate method of defining head position needs to be found. The binder clip had poorly defined edges and often produced a glare.
- Multiple measurements off of a single subject or multiple subjects need to be measured to account for measurement error.

Validation of Upright_Supine Methods Part II: Direct Measurements

A. Introduction

The purpose of this series of experiments is to validate the methods used in the collection of data for the Upright-Supine study. In the Upright_Supine study, ultrasound data is collected from subjects while they are seated upright and while they are lying supine. The concern is that when subjects are in a supine position, their head in the collar may rotate or translate with respect to the ultrasound transducer.

B. Experiment 3

1. Methods

In this study, the relative position of the head to a cervical collar was measured. Two subjects (MLS and MAE) participated in the study. A single point was marked on the cervical collar. To ascertain head position, subjects wore glasses, and two points were marked on the earpiece. The glasses were stabilized with respect to the head by taping them to the subjects' nose. Measurements were taken in both upright and supine position while subjects were seated in a dental chair. Supine position was measured first, since subjects found it easier to maintain their head position when moving from supine to upright than upright to supine. A pillow was placed behind the subject's neck to further stabilize the head.

2. Analysis

Head position was measured by measuring the distance between the point on the cervical collar and each of the points on the glasses (for two sets of measurements for each position). Distance was measured in mm using calipers. Each measurement was taken twice by two measurers to ascertain within measurer and between measurer reliability.

2. Results

As can be seen from the tables below, within measurer reliability is quite good, measurements changed less than 1.5 mm between recordings. Furthermore, the size of the points themselves was ~1.5 mm. Moreover, the differences between upright and

supine head positions was always less than 3 mm, indicating that the subjects moved their heads very little, if at all.

Supine -MS	Measurer			
	ME		AK	
	1 st	2 nd	1 st	2 nd
Distance 1	97.7	96.5	95.3	96.7
Distance 2	122.5	122.8	122.7	121.15

Table 3. Distance measurements for subject MS as recorded by measurer ME and A. Distance 1 is from the collar to the point on the glasses closest to the ear. Distance 2 is from the collar to the point on the glasses furthest from the ear.

Upright - MS	Measurer			
	ME		AK	
	1 st	2 nd	1 st	2 nd
Distance 1	95.1	94.9	95.1	94.5
Distance 2	121.8	120.7	120.6	121.35

Table 4. Distance measurements for subject MS as recorded by measurer ME and A. Distance 1 is from the collar to the point on the glasses closest to the ear. Distance 2 is from the collar to the point on the glasses furthest from the ear.

Supine -ME	Measurer			
	MS		AK	
	1 st	2 nd	1 st	2 nd
Distance 1	95.83	94.79	95.05	96.3
Distance 2	118.23	118.77	119.99	120.03

Table 5. Distance measurements for subject ME as recorded by measurer MS and A. Distance 1 is from the collar to the point on the glasses closest to the ear. Distance 2 is from the collar to the point on the glasses furthest from the ear.

Upright - ME	Measurer			
	MS		AK	
	1 st	2 nd	1 st	2 nd
Distance 1	93.9	93.9	95.4	94.5
Distance 2	116.72	117.16	119.05	120.05

Table 6. Distance measurements for subject ME as recorded by measurer MS and A. Distance 1 is from the collar to the point on the glasses closest to the ear. Distance 2 is from the collar to the point on the glasses furthest from the ear.

B. Experiment 4

1. Methods

Because the subjects in our earlier upright-supine ultrasound studies did not have their heads stabilized with a pillow, subject MAE was also recorded without the pillow. The subject was also instructed to relax and sit comfortably when changing from supine to upright position.

2. Results

As in Experiment 1, there is high level of within experimenter reliability. The differences between upright and supine position are also less than 3 mm, suggesting that even without the support of the pillow, subjects do not move their head very much.

Supine -ME	Measurer			
	MS		AK	
	1 st	2 nd	1 st	2 nd
Distance 1	93.3	92.5	94.16	95.7
Distance 2	116.24	116.55	119.6	119.9

Table 7. Distance measurements for subject ME as recorded by measurer MS and A. Distance 1 is from the collar to the point on the glasses closest to the ear. Distance 2 is from the collar to the point on the glasses furthest from the ear.

Upright - ME	Measurer			
	MS		AK	
	1 st	2 nd	1 st	2 nd
Distance 1	92.72	92.85	94.41	93.9
Distance 2	115.99	116.1	116.3	

Table 8. Distance measurements for subject ME as recorded by measurer MS and A. Distance 1 is from the collar to the point on the glasses closest to the ear. Distance 2 is from the collar to the point on the glasses furthest from the ear.

C. General Conclusions

1. Under the conditions described above, subjects do not change their head positions very much between upright and supine positions. However, we have learned that subjects are more comfortable maintaining a head position from supine to upright than upright to supine.
2. Although our subjects did not move, it would still be useful to make these recordings on all future subjects to confirm that they do not move, as well.