ANALYSIS OF ZYGAPOPHYSEAL JOINT CRACKING DURING CHIROPRACTIC MANIPULATION

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ABSTRACT

Objectives

To determine if there is a relationship between the side of head rotation and the side of joint crack/cavitation during "diversified" rotatory manipulation of the cervical spine.

Design

Fifty subjects were randomly allocated into two groups to receive a single unilateral manipulation to either the left or right side of the cervical spine.

Setting

Macquarie University, Centre for Chiropractic, Summer Hill, New South Wales.

Subjects

Fifty asymptomatic subjects were recruited from the students and staff of the above college.

Intervention

Single, unilateral "diversified", high velocity, low amplitude, rotatory thrust technique.

Main Outcome Measures

Joint cavitation sound wave analysis of Digital Audio Tape (DAT) recordings, taken from two skin mounted microphones positioned on either side of the cervical spine.

Results

All fifty subjects exhibited at least one audible joint crack/cavitation sound during manipulation. Forty-seven subjects (94%) exhibited cracking on the ipsilateral side to head rotation (95% CI, 83.5% to 95.7%). One subject exhibited joint cracking on the contralateral side only, while two subjects exhibited bilateral joint crack sounds. Of fifteen subjects who had a previous history of neck trauma three subjects displayed a statistically significant lower prevalence, for exclusively ipsilateral joint crack (80% vs 100%, P=0.023).

Conclusions

This research suggests that during the "diversified" rotatory manipulation of the cervical spine, utilised in this study, there is a higher occurrence of cavitation/ crack of the zygapophyseal joints on the ipsilateral side to head rotation.

Key Indexing Terms

Chiropractic, zygapophyseal joints, cervical spine, joint crack, joint cavitation, manipulation.

INTRODUCTION

Spinal manipulative therapy (SMT) is commonly used by chiropractors, osteopaths, and by other disciplines of manual therapy, for the treatment of spinal pain. A technique often employed and aimed at the restoration of normal spinal joint motion is the high velocity, low amplitude, thrust technique (HVT). Greenman (1) states that this technique is one of the oldest and most widely used forms of manual medicine and remains one of the most frequently used forms of manual medicine. DiGiovanni (2) also states that the HVT is the best known of all manipulative techniques and states that these techniques may in fact be the first type of manual medicine ever devised. The application of this technique is often accompanied by an audible cracking sound(2,3,4,5,6,) which is considered by some authors to be either essential for the success of the treatment, or at least an important part of the process(5,6,7,8,9), whilst others place no special significance on the cracking sound(2,10,11). Cassidy(12) goes further and states that the joint crack is integral to the manipulative process, and is what separates manipulation, in general, from mobilisation.

The exact mechanism responsible for this audible cracking sound has been investigated by several researchers,(12,13,14,15) and the accepted theory relates to the cavitation of an intra-articular gas bubble. Unsworth, Dawson and Wright(15), in 1971, published the cavitation theory of joint cracking. In their study they imposed a distractive force to the third metacarpophalangeal (MCP) joint, and demonstrated the formation of a gas bubble, predominantly of carbon dioxide. As the traction force increased across the joint, the joint volume increased and the joint fluid partial pressure decreased, causing the intra-articular gases to be drawn out of solution, creating the gas bubble. A subsequent net flow of fluid into this low pressure region collapsed the gas bubble, producing the audible cracking sound. More recently Cassidy et al(12) confirmed this theory by the use of a series of radiographs taken prior to and post manipulation of the third MCP joint. A radiographically visible gas arthrogram was present in 39 of the 42 joints that produced an audible crack when distracted. Studies by the previous author and others have suggested that after joint cavitation a demonstrable increase in the passive range of motion of the manipulated joint is achieved(7,8,13,14).

It has been assumed, by some authors(16,17,18), based on biomechanical principles, that the side of cavitation is dependent on the type of manipulative thrust employed. With respect to the cervical spine Good(16) in his analysis of diversified type adjustments states, "whether joint cavitation occurs at the right or left zygapophyseal joints appears to be determined by the set-up itself.....on the amount of lateral flexion induced in the adjustment. The greater the amount of lateral flexion towards the side of contact the more likely it is that the joint opposite the segmental contact point will release". Cassidy et al(17) in their study on side posture manipulation for lumbar inter -vertebral disc herniation, conclude that at the point of counter-rotation the upper facet opens and the pivot point shifts to the lower facet. Manipulation moves the motion segment into its paraphysiological zone causing cavitation of the upper facet joint with an associated audible cracking sound, and that the resultant increase in both passive and active ranges of motion are beyond those achieved by the use of mobilisation.

The purpose of this study is to identify if there is a relationship between the side of head rotation and the side of the joint cavitation during "diversified" rotatory manipulation of the cervical spine, in asymptomatic subjects. "Diversified" type manipulations are commonly used by Australian chiropractors(19) and with respect to the cervical spine the "diversified" rotatory HVT is described by Gitelman and Fligg(20) as the most frequently used technique.

MATERIALS AND METHODS

Fifty-one volunteers were recruited from the students and staff at the Macquarie University of New South Wales, Centre for Chiropractic. The age of the subjects ranged from eighteen to forty-six years with the mean being twenty-five years and the sex distribution was thirty-six males and fifteen females.

Each volunteer was instructed to complete a medical history questionnaire which was designed to screen for the possibility of vertebro-basilar insufficiency, other contra-indications for cervical SMT, and previous neck trauma (Appendix 1). Each volunteer then underwent a physical examination which included, bilateral upper limb blood pressure measurements, testing for nerve root and spinal cord compromise, Maigne's test(21) for vertebro-basilar insufficiency, and finally goniometric range of motion testing of the cervical spine, using an OrthoRanger II electronic goniometer (*Figure 1*). Volunteers whose previous history or physical examination revealed any contra -indication to SMT were excluded from the study. If a volunteer displayed any nerve root or spinal cord compromise further sensory and motor testing was undertaken (Appendix 2). One volunteer was excluded from the study due to clinical evidence of cervical radiculopathy.

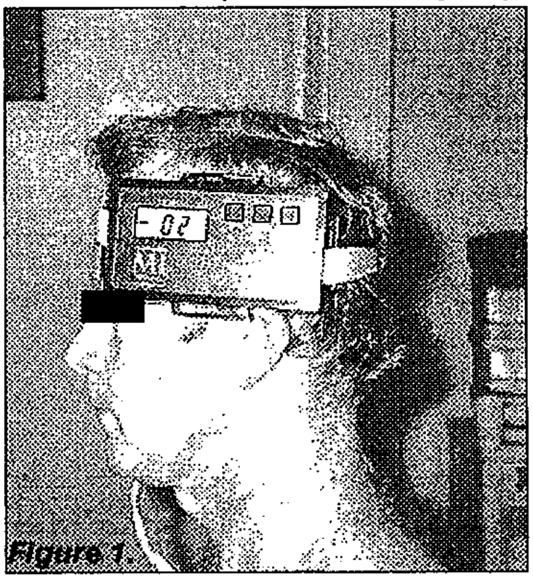


Figure 1.

A total of fifty subjects were included in the trial and were randomly allocated, by the use of computer, into two groups. Group A(24) received a single "diversified" rotatory manipulation to the right C3/4 zygapophyseal joint, and Group B(26) a single diversified rotatory manipulation to the left C3/4 zygapophyseal joint (Table 1).

Table 1.

Subject No.	Side of rotation	Subject No.	Side of Rotation	Subject No.	Side of rotation	Subject No.	Side of rotation	Subject No.	Side of rotation
1	L	11	L	21	R	31	L	41	R
2	R	12	L	22	L	32	L	42	L
3	R	13	R	23	L	33	R	43	R
4	R	14	R	24	R	34	L	44	L
5	R	15	L	25	R	35	R	45	R
6	R	16	L	26	R	36	L	46	R
7	R	17	R	27	L	37	R	47	L
8	L	18	R	28	L	38	L	48	R
9	L	19	L	29	R	39	L	49	R
10	L	20	L	30	R	40	R	50	L

In accordance with the Declaration of Helsinki 1975, and with approval of the Ethics Committee of Macquarie University, all subjects were informed of the purpose of the study and the small inherent danger associated with neck manipulation. Prior to any procedure being undertaken, including testing, volunteers were requested to sign an Informed Consent agreement, before proceeding any further in the trial (Appendix 3 & 4).

After their physical examination and prior to manipulation, each subject had affixed to either side of their neck a Realistic Electrec Condenser omnidirectional microphone. The microphones had been previously calibrated by an acoustic engineer and were found have a decibel differential of less than 0.3 dB. Each microphone was tagged with a right or left marker, corresponding to the left and right channels of the recorder. Each microphone was then supported in a modified plastic syringe cylinder, 2mm from the contact end, so as to avoid direct contact of the microphone with the skin. The cylinder was then positioned slightly anterior to the transverse process of the C2, and affixed to the skin using adhesive tape (*Figure* 2). The microphones were then connected to a Sony DAT Walkman recorder, and the subject number and corresponding side of rotation together with the side of contact or thrust was verbally recorded, as well as the verbal identification of the left or right microphone. The subject then received manipulation with head rotation to either the right or left, as per the random allocation. The resultant joint crack or cracks from the manipulation were recorded for later analysis. After twenty of the subjects had been manipulated the left tagged microphone was placed on the right side of the neck, and right tagged microphone on the left side, thereby minimising any possible phase error within the recording equipment.

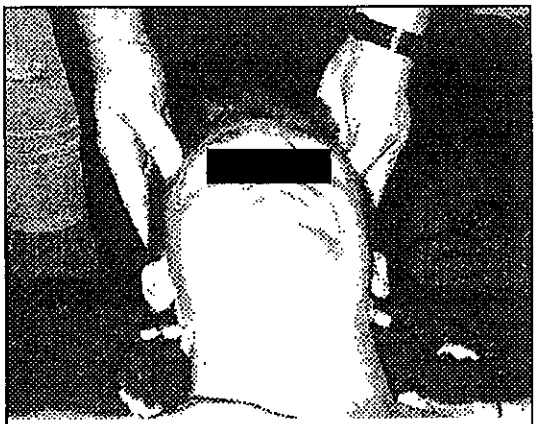


Figure 2

Manipulation

The type of manipulation employed was that of a "diversified" rotatory type, in which the subject's neck was palpated in the supine position. The C3/4 zygapophyseal joint was nominally located by static palpation with the index finger of the contact hand, whilst the head was cradled and supported at the occiput by the other hand. The index finger of the contact hand was then replaced with the thumb of the contact hand, with the fingers supporting the occiput, while the other hand grasped the subjects chin from the opposite side. The head was then rotated 45° away from the contact or thrusting hand, and supported by the opposite forearm. The contact thumb was then moved slightly inferior so as to contact the articular pillar of C4. With the stabilising hand firmly supporting the head, the thumb of the contact hand then took the joint into a position just short of its paraphysiological range of motion, by pressure applied in a lateral to medial direction. At the point of joint resistance, deemed to be appropriate by the clinician, and the point of greatest muscle relaxation by the patient, a high velocity, low amplitude thrust was made in a lateral to medial, and rotatory direction. The thrust was delivered without movement of the supporting or stabilising hand, and was achieved by a rapid rotatory movement of the wrist (*Figure 3*). All manipulations were executed by the same practitioner for all subjects.

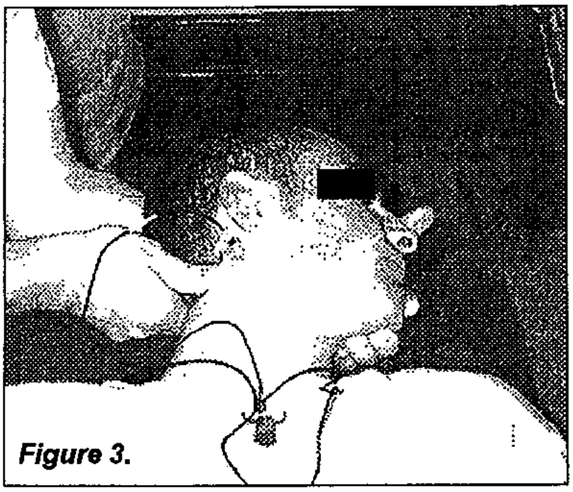


Figure 3.

Recording and wave form analysis

The sounds of the joint crack or cracks were recorded in stereo with a Sony DAT Walkman, TCD-D7, the left and right channels of the recorder corresponding with the left and right microphones. The resultant recordings were then analysed by a computer which was equipped with a Media Vision Pro Audio Card and a Video for Windows, Wave Edit software package. Each wave form was analysed at 16 Bits, giving a dynamic range of 65,000+ levels, and at a frequency of 44.1 kHz, with a hard copy of the edited wave forms recorded using a laser printer(Appendix 5).

Statistical Analysis

The data was analysed using the SAS-PC statistical package(SAS Institute, Carey, North Carolina). The overall prevalence of joint cavitation occurring on the side of head rotation was estimated using the exact 95% confidence interval for binomial proportion[22]. The examination of prevalence differences between the side of rotation ,sex, history of previous trauma, and age were performed using Fisher's Exact test, and the Wilcoxon rank-sum test (for age). The joint effect of these factors on the prevalence of joint cavitation on the side of head rotation was examined using logistic regression, although only a limited assessment was possible due to the sparseness of the data.

Hypotheses

Ho. The null hypothesis states that during unilateral rotatory cervical spine manipulation, the side of head rotation will have no effect on the side of joint crack/cavitation.

Equipment

1. Sony TCD-D7 DAT Walkman recorder. (Sony (Australia) Pty. Ltd. Surrey Hills, Victoria.)
2. Realistic Electrec condenser microphones. (Tandy Electronics, Chadstone, Victoria.)
1. 386 DX IBM compatible computer.
1. Media Vision Pro Audio Card. (Media Vision. Fremont, California, USA.)
1. Video for Windows, Wave Edit software package. (Microsoft Pty. Ltd. South Yarra, Victoria.)
1. Hewlett-Packard HP4L laser jet printer. (Hewlett-Packard Australia Limited, Blackburn North, Victoria.)
1. OrthoRanger II Electronic Goniometer. (MIT (Aust) Pty. Ltd. Artarmon, NSW.)
2. 2.5ml Terumo Syringes. (Terumo Australia Pty. Ltd. Mordialloc, Victoria.)
1. Roll Leukotape P. (Beiersdorf Australia Ltd. Scoresby, Victoria.)

Limitations of the study

The main limitation of this study relates to the fact that only one practitioner administered the SMT which could bias the results due to the individualisation of the technique employed, and thereby diminish the external validity of the study. In the authors experience certain individualistic changes or nuances are developed by different practitioners of SMT for the same technique, either from when originally taught, or during the years that particular technique has been used by the individual. These changes, even though subtle, may change the biomechanical actions and outcomes of that technique and therefore must be considered as a confounding factor in this study.

Further, the shape and orientation of the facet joints, in conjunction with the coupled movements of the vertebrae above and below, governs the degree of range of motion in any given plane, and therefore, presumably, the relative ease or difficulty the joint will cavitate in any given plane.

There is also some evidence to suggest that the instantaneous axis of rotation changes in the presence of discogenic spondylosis(23) and or pain(24), which may further influence the side or level of joint cavitation.

RESULTS

Fifty subjects were recruited in the trial and all met the previously discussed inclusion criteria. The fifty subjects were composed of thirty-six males and fourteen females, ranging in age from 18-46 years, with an average age of 25 years.

Fifteen subjects stated that they had a previous history of neck trauma. Goniometric range of motion testing of all subjects revealed an average of 85° for both left and right rotation, with an average asymmetry of 6°. Nine subjects displayed rotational asymmetries of 10° or more, with one subject recording asymmetry 20° (Table 2).

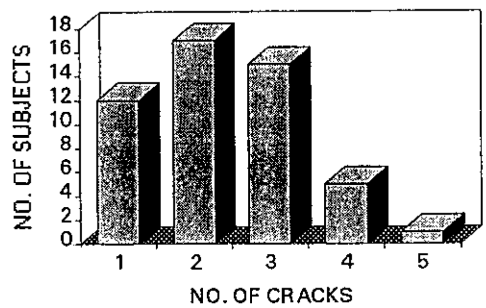
Table 2.

SUBJECT NUMBER	MALE FEMALE	AGE	HISTORY OF TRAUMA	RIGHT ROTATION	LEFT ROTATION	DIFFERENCE	SIDE OF ROTATION	SIDE OF CRACK 1	SIDE OF CRACK 2	SIDE OF CRACK 3	SIDE OF CRACK 4	SIDE OF CRACK 5
1	F	46	NO	90	82	8	L	L	L			
2	F	23	NO	90	86	4	R	R	R	R		
3	M	22	YES	98	104	6	R	R				
4	M	38	YES	81	83	2	R	R	R	R		
5	F	23	NO	89	100	11	R	R				
6	M	22	YES	93	84	9	R	R	R			
7	F	24	NO	80	80	0	R	R				
8	M	35	NO	87	71	16	L	L	L			
9	M	24	YES	92	88	4	L	L				
10	M	23	YES	93	77	16	L	L	L	L	L	
11	M	23	YES	95	91	4	L	L	L	L	L	
12	M	22	NO	95	95	0	L	L	L	L	L	
13	M	29	NO	75	85	10	R	R				
14	M	24	NO	90	82	8	R	R	R			
15	M	24	YES	83	83	0	L	L				
16	M	27	NO	89	90	1	L	L				
17	F	22	YES	83	85	2	R	R	L**	R		
18	M	23	YES	74	94	20	R	R	R	R		
19	F	22	YES	88	85	3	L	L	L			
20	F	22	NO	86	92	6	L	L	L			
21	M	23	YES	84	91	7	R	R	R			
22	F	24	YES	91	85	6	L	L				
23	M	25	NO	90	98	8	L	L	L			
24	M	22	NO	85	85	0	R	R	R			
25	M	24	NO	67	78	11	R	R	R	R	R	
26	F	24	YES	78	76	2	R	R				
27	M	31	YES	86	84	2	L	L	L	R**		
28	M	22	NO	86	90	4	L	L	L	L		
29	M	23	NO	90	84	6	R	R	R			
30	M	24	NO	76	77	1	R	R				
31	M	25	NO	100	95	5	L	L	L	L	L	L
32	M	21	NO	76	82	6	L	L	L			
33	F	22	NO	78	90	12	R	R	R			
34	F	35	NO	90	100	10	L	L	L			
35	F	39	NO	62	68	6	R	R	R			
36	M	26	NO	83	79	4	L	L	L			
37	M	18	NO	90	89	1	R	R	R			
38	M	22	NO	69	61	8	L	L	L	L		
39	M	24	YES	90	92	2	L	R**	R**			
40	M	22	NO	86	93	7	R	R	R	R		
41	M	22	NO	84	90	6	R	R	R	R		
42	F	21	NO	87	94	7	L	L	L	L		
43	M	20	NO	79	94	15	R	R	R	R		
44	M	30	NO	90	96	6	L	L				
45	M	21	NO	75	77	2	R	R	R	R		
46	M	22	NO	80	83	3	R	R	R	R		
47	M	24	NO	77	82	5	L	L	L	L	L	
48	F	22	NO	84	77	7	R	R	R	R		
49	M	20	NO	73	70	3	R	R	R	R		
50	M	32	NO	89	93	4	L	L				
Sum	MALE	36	Y15/N35	4226	4226	296	50	50	38	21	6	1
Avg	FEMALE	14		85	85	6						

** Signifies crack opposite head rotation

All fifty manipulations resulted in at least one audible joint cavitation sound and in total the fifty subjects combined produced 116 individual joint cracks (Table 2). Although often difficult to discern audibly, analysis of the recorded sound wave patterns revealed that in only twelve subjects a single joint crack was produced. The majority of the subjects (64%) produced either two (17) or three (15) distinct cavitation signals, while five subjects produced four and one five separate joint cavitation signals (*Figure 4*). Six subjects exhibited joint cracking while the joint was being tensioned, during the set-up procedure, and prior to the manipulative thrust, but in all six subjects further joint cracks were produced when the thrust was applied (Table 2).A crack on the ipsilateral side to head rotation was defined as occurring when all detected cracks occurred on that side.

Figure 4.



Forty-seven of the fifty subjects (94%) exhibited cracking on the ipsilateral side to head rotation (95% CI, 83.5% to 95.7%)(Table 3). Of the three subjects who exhibited cracking on the contralateral side to rotation, only one subject produced purely contralateral cracking, the remaining two subjects displaying cracking on both sides, and in these two subjects the contralateral cracks were not the primary cracks. The prevalence for joint cavitation on the ipsilateral side to rotation was significantly lower for those subjects who had a history of neck trauma as compared to those without a history of neck trauma (80% vs 100%, respectively, P=0.023, Table 3). Other subgroup comparisons of prevalence's of cavitation on the ipsilateral side to rotation, for age and sex, did not display statistically significant differences (Table 3). The limited logistic regression modelling did not result in conclusions differing from those above.

TABLE 3

- Percentage of subjects exhibiting joint cracks on the ipsilateral side to head rotation.

Variable	No. of Subjects	No. (%) with all ipsilateral cracks	P-value *
All subjects	50	47 (94.0) 95% CI(83.5,98.7)	-
Side of rotation-			
Right	26	25 (96.2)	
Left	24	22 (91.7)	0.602
Sex-			
Male	36	34 (94.4)	
Female	14	13 (92.9)	1.000
Previous trauma-			
Yes	15	12 (80.0)	
No	35	35 (100.0)	0.023
Age (years)		Median (Range)	
All subjects	50	23 (18-46)	
Ipsilateral cracks	47	23 (18-46)	
Contralateral cracks	3	24 (22-31)	0.589 ##

* Fisher's Exact test
Wilcoxon rank-sum test

The analysis of the recorded sound wave forms was done using the Wave Edit programme utilising 44kHz option and thus a sample range of 44,000 samples per second (*Figures 5 & 6*). This analysis revealed that the average length of all joint crack sounds combined was 170 samples (Table 4).The actual period of time between individual joint cracks in subjects who exhibited more than one crack varied on average from 1522 samples, between cracks one and two, to 374 samples between cracks four and five (Table 4). Table 5 depicts the maximum peak amplitude for each joint crack for both left and right channels, together with the percentage ratio between both channels, with the latter averaging 22.9% for all recorded cracks.

Figure 5.

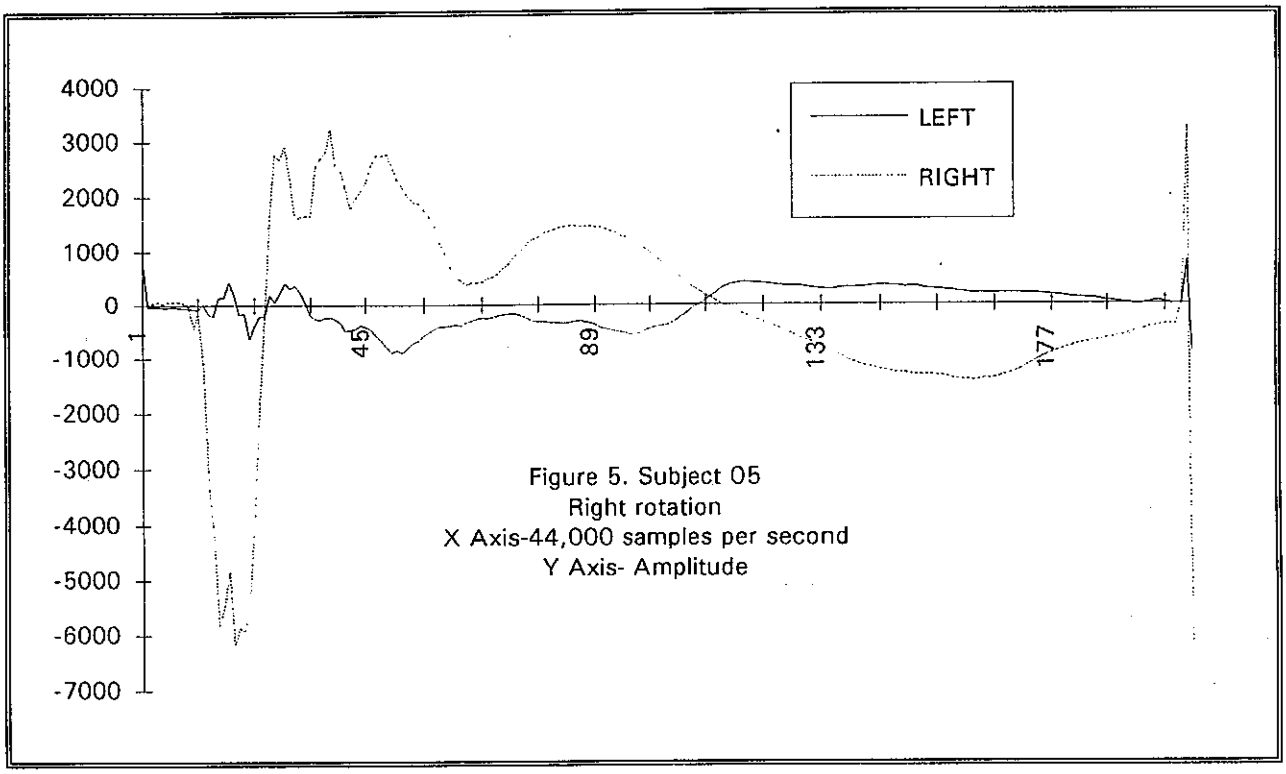


Figure 6.

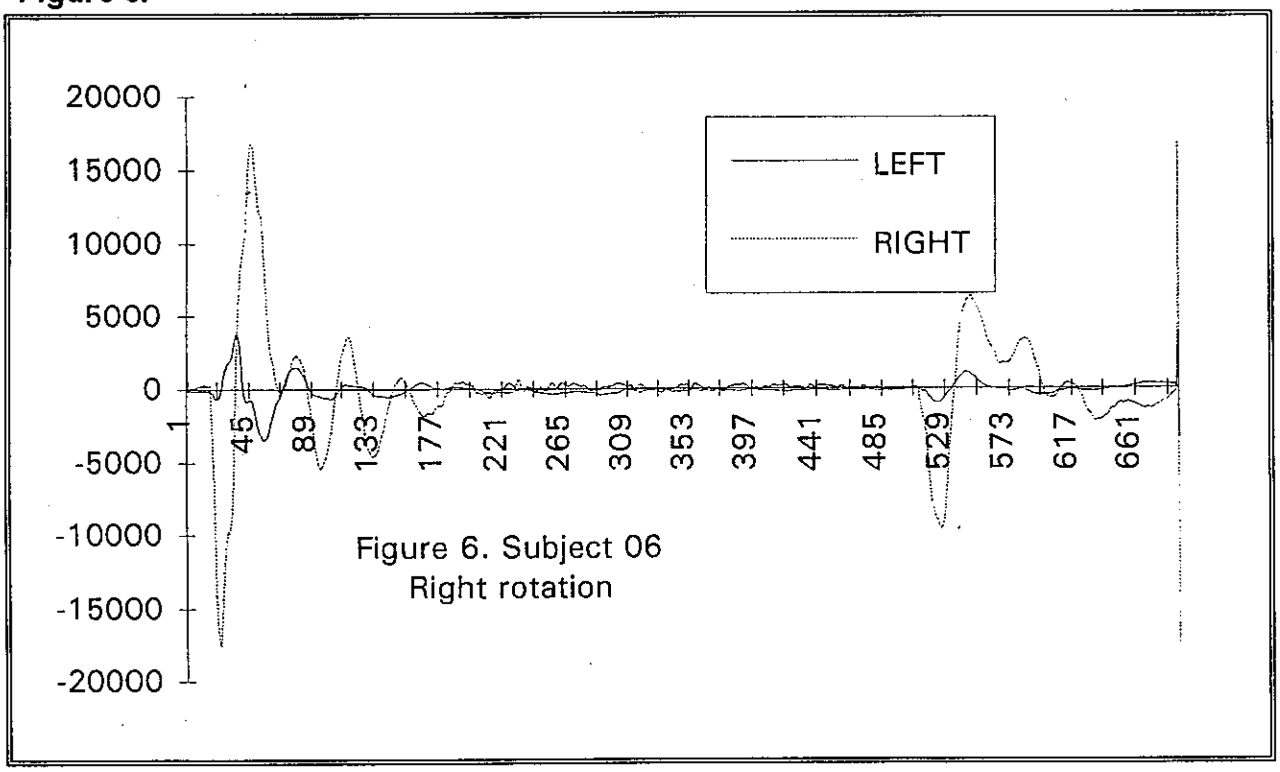


Figure 5. depicts a typical computer generated wave form of single joint crack while *Figure 6.* depicts a typical multiple joint crack wave form.

Table 4.

SUBJECT NO.	LENGTH OF CRACK 1	LENGTH OF CRACK 2	LENGTH OF CRACK 3	LENGTH OF CRACK 4	LENGTH OF CRACK 5	TIME B/T CRACK 1-2	TIME B/T CRACK 2-3	TIME B/T CRACK 3-4	TIME B/T CRACK 4-5
1	228	188				1588			
2	178	315	187			314	566		
3	350								
4	67	17	101			1102	406		
5	182								
6	198	178				497			
7	103								
8	102	257				2067			
9	204								
10	252	271	51	191		1187	1823	396	
11	140	122	187	156		ON SETUP	129	729	
12	117	143	52	52		892	1771	1191	
13	150								
14	46	78				429			
15	127								
16	208								
17	215	107	163			740	1803		
18	96	30	112			1008	942		
19	134	71				524			
20	167	154				2173			
21	109	181				ON SETUP			
22	131								
23	96	67				2139			
24	110	95				923			
25	156	108	CREPITUS	CREPITUS		16082	1077		
26	271								
27	84	78	44			ON SETUP	1035		
28	44	148	95			1146	2942		
29	85	71				2222			
30	149								
31	260	327	138	651	132	ON SETUP	ON SETUP	2656	374
32	239	117				785			
33	111	115				1232			
34	147	91				362			
35	49	93				388			
36	152	92				474			
37	98	138				1461			
38	120	162	126			1060	1257		
39	159	155				515			
40	139	192	147			1218	779		
41	267	255	180			719	1055		
42	160	156	155			1795	1187		
43	194	283	258			ON SETUP	2242		
44	103								
45	345	251	204			ON SETUP	609		
46	108	157	147			1410	17		
47	143	184	164	208		383	231	1853	
48	139	153				360	502	106	
49	240	234	212			ON SETUP	349		
50	834								
TOTAL	8506	5834	2723	1258	132	47195	20722	6931	374
AVERAGE	170	154	143	252	132	1522	1036	1155	374

Table 5.

	CRACK 1			CRACK 2			CRACK 3			CRACK 4		
SUBJECT	PEAK AMPLITUDE			PEAK AMPLITUDE			PEAK AMPLITUDE			PEAK AMPLITUDE		
NO.	LEFT	RIGHT	% RATIO	LEFT 2	RIGHT 2	% RATIO	LEFT 3	RIGHT 3	% RATIO	LEFT 4	RIGHT 4	% RATIO
1	6716	2387	35.5%	10676	5995	56.2%						
2	1362	6411	21.2%	731	3611	20.2%	1770	3831	46.2%			
3	768	5217	14.7%									
4	203	1368	14.8%	125	2112	5.9%	880	3877	22.7%			
5	902	6175	14.6%									
6	3482	17612	19.8%	961	9668	9.9%						
7	1646	6382	25.8%									
8	1533	386	25.2%	6045	4057	67.1%						
9	10490	883	8.4%									
10	2378	537	22.6%	10664	2434	22.8%	2809	128	4.6%	1817	537	29.6%
11	3275	433	13.2%	4751	521	11.0%	5431	965	17.8%	4433	237	5.3%
12	10152	760	7.5%	7230	853	11.8%	4056	27	0.7%	3480	498	14.3%
13	2762	8241	33.5%									
14	582	3858	15.1%	923	9002	10.3%						
15	10041	1503	15.0%	750	129	17.2%						
16	25816	9349	36.2%									
17	4383	7611	57.6%	1304	0	0.0%	3830	5646	67.8%			
18	1976	4516	43.8%	729	1736	42.0%	2481	7710	32.2%			
19	6645	1553	23.4%	2683	710	26.5%						
20	7656	1523	19.9%	3601	633	17.6%						
21	2846	21632	13.2%	4697	28721	16.4%						
22	24792	4066	16.4%									
23	3538	872	24.6%	5407	447	8.3%						
24	996	7128	14.0%	445	3983	11.2%						
25	1093	4418	24.7%	98	1644	6.0%						
26	3369	11693	28.8%									
27	3948	455	11.5%	18777	2618	13.9%	249	1760	14.1%			
28	2502	513	20.5%	11500	1232	10.7%	7799	964	12.4%			
29	1486	3827	38.8%	321	1396	23.0%						
30	1161	11285	10.3%									
31	608	180	29.6%	3041	1804	59.3%	4757	1084	22.8%	8175	2170	26.5%
32	3843	1684	43.8%	5895	768	13.0%						
33	2469	2930	84.3%	1575	2694	58.5%						
34	6739	1627	24.1%	10264	1748	17.0%						
35	1125	10991	10.2%	1006	5648	17.8%						
36	5335	1088	20.4%	2568	510	19.9%						
37	1695	3600	47.1%	748	4666	16.0%						
38	10797	989	9.2%	6662	620	9.3%	12654	1790	14.1%			
39	755	7839	9.6%	701	6528	10.7%						
40	950	8328	11.4%	3066	8291	37.0%	1235	6642	18.6%			
41	2239	11160	20.1%	1665	6671	25.0%	658	2401	27.4%			
42	4094	362	8.8%	5477	547	10.0%	3239	276	8.5%			
43	1479	17187	8.6%	476	3416	13.9%	959	9331	10.3%			
44	3129	516	16.5%									
45	2753	5909	46.6%	1245	5377	23.2%	1134	5294	21.4%			
46	1524	4800	31.8%	631	6606	9.6%	654	3142	20.8%			
47	4053	1326	32.7%	3594	1115	31.0%	3223	1322	41.0%	7071	2632	37.2%
48	1470	8566	17.2%	1113	6989	15.9%	1739	2871	60.6%			
49	1760	4801	36.7%	703	3220	21.8%	2036	8850	23.0%			
50	29363	4284	14.6%									
Avg			23.9%			20.9%			24.3%			22.6%
Max			84.3%			67.1%			67.8%			37.2%
Min			7.5%			0.0%			0.7%			5.3%

DISCUSSION

Previous research

Unfortunately the vast majority of research on joint cavitation(12,13,14,15,25) has concentrated not on the spine but on the metacarpophalangeal joints (MCP), due to their accessibility and the ease with which they can be cavitated. These previous studies have however provided the now well entrenched explanation as to the mechanism of the joint crack(15).

Scott and Meal(25) mention in their analysis of the MCP joint crack that some recordings were made of cervical spine joint cracks, and then briefly conclude that the recorded sound wave patterns of the MCP joints were the same as those recorded for manipulation of the cervical spine.

The only other reference cited in the chiropractic literature, relating to the recording of spinal joint cracking was that by Herzog in 1991(26). A later paper in 1993 on the "Forces exerted during spinal manipulative therapy"(27) by that author and others, used the same data with regard to spinal joint cracking. Herzog measured the treatment forces exerted by chiropractors during SMT on the thoracic spine, in conjunction with cavitation signals of the spinal joints. In Herzog's experiment SMT was applied to the T4 transverse process and sound recordings were made using small skin mounted accelerometers, mounted on the T3 spinous process. Herzog concluded from the sound wave analysis that the frequency content was similar to that found for confirmed cavitation of the MCP joints in the earlier research by Scott and Meal.

In 1986 two dentists, Woods and West, published a paper "A comparison of the temporo-mandibular joint sounds with the sounds from other joints of the body," (28), and suggest that their study was the first to actually record the sounds involved in the manipulation of the vertebral joints. A review of the available literature would tend to confirm this claim. With the help from local chiropractors they recorded sounds from 64 manipulated spinal joints, 29 cervical, 10 thoracic, and 25 lumbo-sacral, as well as 27 MCP and 25 metatarsophalangeal joints. They then compared these sounds to the sounds emanating from non-manipulated but dysfunctional temporomandibular joints(TMJ). They concluded that the sound wave form of the manipulated joints showed little reproducibility from one manipulation to the next, and that only the sounds from the cervical joints were not significantly different from the so called "soft" TMJ sounds, while the manipulated MCP joint sounds were not significantly different from the so called "hard " TMJ sounds. As the TMJ sounds were not produced by manipulation but from dysfunctional joints and that these sounds were not significantly different from the manipulated cervical joint sounds, the authors theorised that both joint sounds involve in part the rubbing of joint surfaces over each other. Furthermore they conclude that the "hard" TMJ clicks, being similar to the sound of the manipulated MCP joints, were at least in part the due to the previously explained cavitation theory(15).

Cavitation and manipulation

There are many terms used to describe the lesion to which practitioners of SMT direct their attention, and still many more different types of manipulation employed to treat that lesion.

The lesion is identified within the chiropractic, osteopathic, and medical literature by terms including, vertebral subluxation, (Homewood(29)); osteopathic lesion (Stoddard(30)); somatic joint dysfunction (Mennell(31)); vertebral subluxation complex (Schafer and Faye(32)); somatic dysfunction (DiGiovanni(33)); functional spinal lesion (Triano(34)); and manipulable lesion (Halderman(35)). These various terms are defined by their authors as having certain characteristics, but one common feature to all the definitions is that of restricted or abnormal vertebral joint motion.

Similarly the manipulative procedures used to treat this joint dysfunction are numerous and differ not only from discipline to discipline , but also within each discipline, but one common therapeutic goal of all the manipulative techniques is the restoration of normal joint function(36,37,38,39,40,).

The HVT is said to be the most commonly used manipulative technique for this purpose(1,2), but their are numerous variations of this technique employed to treat similar if not the same type of manipulable lesion.

In general terms the HVT involves positioning the joint at its passive end range of motion, at which point a resistance is encountered , due to the tensioning of the joint capsule. A carefully graded and directed thrust is then applied to the joint, which takes the joint from its passive end range of motion into the paraphysiological space. the force must be great enough to overcome co-adaption of the joint surfaces and separate them into the paraphysiological space without taking them beyond their anatomical integrity (*Figure 7*). The sudden separation of the joint surfaces results in the phenomenon of joint fluid cavitation producing the characteristic cracking sound(41). In the opinion of some notable authors, in the field of SMT(3,9,12), it is this fluid cavitation that separates manipulation from mobilisation and results in an increase in the passive and active ranges of motion. Of the authors on SMT who place little significance on the joint crack most agree that if nothing else it does indicate that the joint surfaces have indeed been separated(5,6,7,10).

MOBILISATION & MANIPULATION

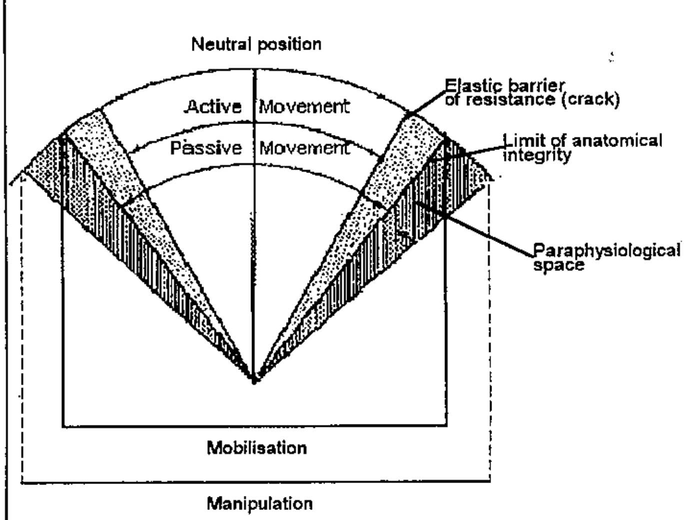


Figure 7. **(After Sandoz 1976)**

The question must then be addressed is from what joint level and from what side does this cracking sound emanate in any given manipulative thrust? A review of the more popular texts on SMT provides the reader with a variety of HVTs, which are often used for the same type of joint restriction.

For example a patient presenting with restricted left cervical rotation would be treated according to Maigne(42), with the patient supine, by turning the head toward the side of least restriction, ie. to the right, the "Rule of no pain and free movement". This he states "is contrary to what is generally believed, by turning the head to the right that one performs the manipulation which will improve the head rotation to the left". The radial border of the left hand is then placed against the joint to be manipulated, on the left, and the neck is placed in extension before taking up the slack in further right rotation. A sudden thrust with the right index finger is then made in order to locally exaggerate this movement. Maigne further states that this technique can be used at any level of the cervical spine, either with extension, flexion, and or lateral flexion. Therefore according to Maigne this manipulative technique gaps the facet joints on the left when the spine is in right rotation and extension and even with the added movements of flexion and or lateral flexion.

Greive(18) states that left lateral flexion in combination with right rotation will produce facet apposition on the left and facet gapping on the right.

Erner(43) describing one osteopathic HVT for restricted left rotation turns the neck to the left, with his left hand, into the "motion barrier" after first slightly extending the neck. The neck is then laterally flexed to the right and a rotatory thrust made with the second metacarpal joint of the right hand, behind the right transverse process of the vertebra to be manipulated.

Bourdillon(44) describes a technique for restricted motion at C5-6, with maximum "tissue tension" on the left side. The patient is sitting astride the table, facing the doctor, whose distal phalanx of the right index finger hooks over the spinous process of the C5 vertebra, while the interphalangeal joint comes over the lateral mass of that vertebra.

The left hand stabilises the head. The head is then put into either right or left lateral flexion. and into either flexion or extension, over the index contact until the barrier of motion is met. Rotation is then added by pulling on the index finger while rotating the head to the right. The thrust is made by with a short sharp increase in the rotatory pressure, simultaneously with both hands.

Cassidy(45) in his study on the effect of manipulation on range of motion in the cervical spine uses yet another technique. Although not fully described in the study this HVT involves rotating the head away from the side of pain, and contacting the articular pillar on the painful side with the third finger of the contact hand. The thrust is made in the same direction as the head rotation. Cassidy then states that this manoeuvre is accompanied by a crack that is the result of a synovial fluid cavitation in the facet underlying the contact finger.

Nansel et al(46) studied the effectiveness of upper versus lower cervical SMT on the amelioration of passive rotational versus lateral-flexion end-range asymmetries in otherwise asymptomatic patients. The technique used for rotational asymmetries was either bilateral manipulation to the C2-3 spinal level or bilateral manipulation to the C6-7 spinal level, in the sitting position. In this manipulation the doctor stood behind and slightly toward the side to be manipulated. For manipulation of the left side, the doctors stabilising or right hand was placed on the top of the patient's The thumb of the contact hand was then placed on the ramus of the jaw, forming an arch between the thumb and index finger. The stabilising hand was then placed on the posterolateral surface of the cervical spine , opposite the side of contact, and the chin then elevated and the head laterally flexed to 10-15°, then rotated towards the side to be manipulated. After the appropriate tension was achieved, with pressure from the index contact, the thrust was made with a rotational motion of the wrist and forearm, lifting the spinous up while moving it anteriorly and medially.

Nansel concludes that "this procedure almost always yielded multiple audibles, suggesting multiple segment involvement".

Other authors like Corrigan and Maitland(47), Crisp(48), Schaffer and Faye(49), Fisk(50) and Grieve(51) to name just a few have either different HVTs or variations on those HVTs described above, all designed to treat the manipulable lesion.

Most of the above authors emphasise specificity as to the correct side, spinal level, and the type of HVT that should be used for a given manipulable lesion, and criticise any technique that employs a "shotgun" approach". Cassidy et al(41) in reviewing previous studies of spinal manipulation are critical of the criteria used to select the level and direction of the manipulative treatments. They state that in some studies the manoeuvres are applied non-specifically, and that in such cases it is possible that the direction and level of the manipulation is wrong.

This research would suggest that, at least in asymptomatic subjects without a history of neck trauma, the side of joint crack/cavitation according to Good's(16) biomechanical model and the rationale of certain HVTs must be questioned. The null hypothesis Ho is therefore rejected, with respect to the HVT used in this study, as there is a definite pattern to the side of joint crack/cavitation, which is contralateral to the side of primary contact or thrust and ipsilateral to the side of head rotation. The question of whether it is the side of rotation, the manipulative thrust employed, or the side of primary contact that determines the side of cavitation is yet to be answered. However this study should form the foundation for further research in order to improve the therapeutic protocol, thus making SMT more side specific and avoiding the "shotgun" approach. This in turn should