COMPARISON BETWEEN UPPER CERVICAL X-RAY LISTINGS AND TECHNIQUE ANALYSES UTILIZING A COMPUTERIZED DATABASE

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ABSTRACT

X-ray analysis has historically been the assessment of choice for analyzing the occipito-atlanto-axial subluxation complex. There are also several quick non-radiographic methods that are used clinically to test for atlas subluxation, such as leg checks, palpation and thermography. If non-radiographic methods can be found that accurately predict atlas misalignment, they might provide a safer alternative for routine screening of patients. Although non-radiographic methods are reputed to be accurate measures of upper cervical subluxation, a thorough investigation into the agreement between methods has yet to be done.

This retrospective study was carried out to assess the level of agreement between the Grostic Procedure of upper cervical x-ray analysis and six other methods of assessing upper cervical subluxation. Patient information in this study was derived from the files of a doctor of chiropractic in private practice. Clinical findings were recorded in a specially designed computerized database. The database was then queried to construct agreement tables for the various assessments. The

Kappa statistic was calculated and used as an indication of agreement.

The data presented in this retrospective study shows that there is a poor correlation between upper cervical x-ray analysis and the other analyses presented. The results suggest that while non-radiographic methods might be useful as pre- and post-adjustment screening checks, they should not be relied on to provide misalignment listings for adjustment.

Key words: occipito-atlanto-axial subluxation complex, Grostic Procedure, adjustment, computerized database.

INTRODUCTION

Although the existence and description of the vertebral subluxation complex has been debated in the chiropractic and medical literature, it is still considered by many to be the fundamental tenet of the chiropractic profession (1-11). Due to the unique anatomy of the upper cervical spine, (12,13) the analysis of subluxations in this area pose a challenge for many doctors of chiropractic; therefore a variety of methods have been devised. Medical physicians also have used various methods to measure misalignments of the upper cervical spine. After the application of traction, manipulation or surgery, they have verified the subluxation's reduction with the use of post x-rays and CT scans (12, 14-26). Since many chiropractors base their treatment on the analysis of the vertebral subluxation complex, the accuracy of this analysis is vital for the quality and safety of chiropractic patient care.

There exist within the chiropractic profession several different methods for determining the misalignment components of the upper cervical subluxation. From the 1920's to the present, x-rays have been used to determine adjustment listings in virtually all upper cervical specific techniques. One particular x-ray analysis method, pioneered by Dr. John F. Grostic (27-29), has formed the basis for a family of x-ray analysis procedures including Orthospinology (30), NUCCA (31), Orthogonality (32), Life Cervical (33) and early versions of the Pettibon method (34). This system has been used and tested clinically in various settings since the 1940's, and has been shown to have high inter- and intra-examiner reliability in recent reliability studies (35-38).

The Grostic Procedure employs x-ray analysis to quantify the lateral and rotational misalignments between atlas and axis as well as atlas and occiput. The analytical procedure examines the spatial orientation of the atlas, the geometry of the articular surfaces, and the misalignment configuration to arrive at an effective correction vector. In addition to the x-ray analysis, the Grostic Procedure uses specific methods to ensure the precision of the x-ray analysis. There are also post adjustment re-evaluation procedures which allow the doctor to assess the effectiveness of the adjustment and, of equal importance, to fine-tune the adjustment to the individual patient (28).

In general, the Grostic nasium x-ray analysis is used to determine an upper angle, the angle between the vertical center of the skull and the plane of the atlas, and a lower angle formed between the atlas plane and the center of the lower cervical spine. Atlas "laterality" is found by looking for an acute upper angle. The Grostic analysis of the vertex film is used to determine atlas rotation with respect to the skull.

Subluxations analyzed following the Grostic

Procedure fall into two general patterns: opposite angles and kink subluxations. In the kink pattern, represented in figure 1, acute angles are seen on the same side of the spine in both the upper and lower angles. In the opposite angles pattern, the acute upper and lower angles are on opposite sides of the spine, as shown in Figure 2.

The Grostic analysis also lists the position of the C2 spinous process with respect to the atlas. An inferior axis spinous indicates that the axis spinous process has misaligned to the same side of atlas laterality (Figure 2). A superior axis spinous indicates that the axis spinous process has misaligned to the opposite side of atlas laterality, as shown in figure 1 (29).

Many chiropractic techniques, besides the Grostic based te niques mentioned above, have specific methods for assessing and adjusting the upper cervical spine. Those that do not use x-ray analysis use other clinical indicators to decide whether the atlas is misaligned, and in which direction. I was taught in chiropractic college that any of these clinical indicators should produce the same results. This conclusion was based on the clinical experience of my instructors and their general understanding of the techniques. As a matter of curiosity, I decided to test several non-radiographic methods of determining atlas subluxation using data already collected on the patients in my private practice of chiropractic.

The following six hypotheses were tested:

1. Activator analysis can be used to determine atlas laterality, rotation and axis rotation.

2. Posture analysis can be used to determine atlas laterality, rotation and axis rotation.

3. Restricted cervical range of motion can be used to determine atlas laterality, rotation and axis rotation.

4. Static palpation can be used to determine atlas and axis rotation.

5. The side of the colder infrared temperature at the C1 fossa is the side of atlas laterality.

6. Kink subluxations will usually cause a functional short leg on the side of atlas laterality. Opposite angle subluxations will usually cause a functional short leg on the opposite side of atlas laterality.

Although non-radiographic methods are reputed to be accurate measures of upper cervical subluxation, a thorough investigation into the agreement between methods has yet to be done. This study will compare upper cervical listings found using the Grostic Procedure x-ray analysis to those found with various other non-radiographic methods. If non-radiographic methods can be found that accurately predict atlas misalignment, they might provide a safer alternative for routine screening of patients.

METHODS

In examining patients in my practice, I routinely carry out and record checks from several different chiropractic methods. The results of each examination are stored in a custom database that I use for patient tracking and research.

X-ray Analysis

Lateral, nasium and vertex radiographs were taken routinely as part of the patient's care.

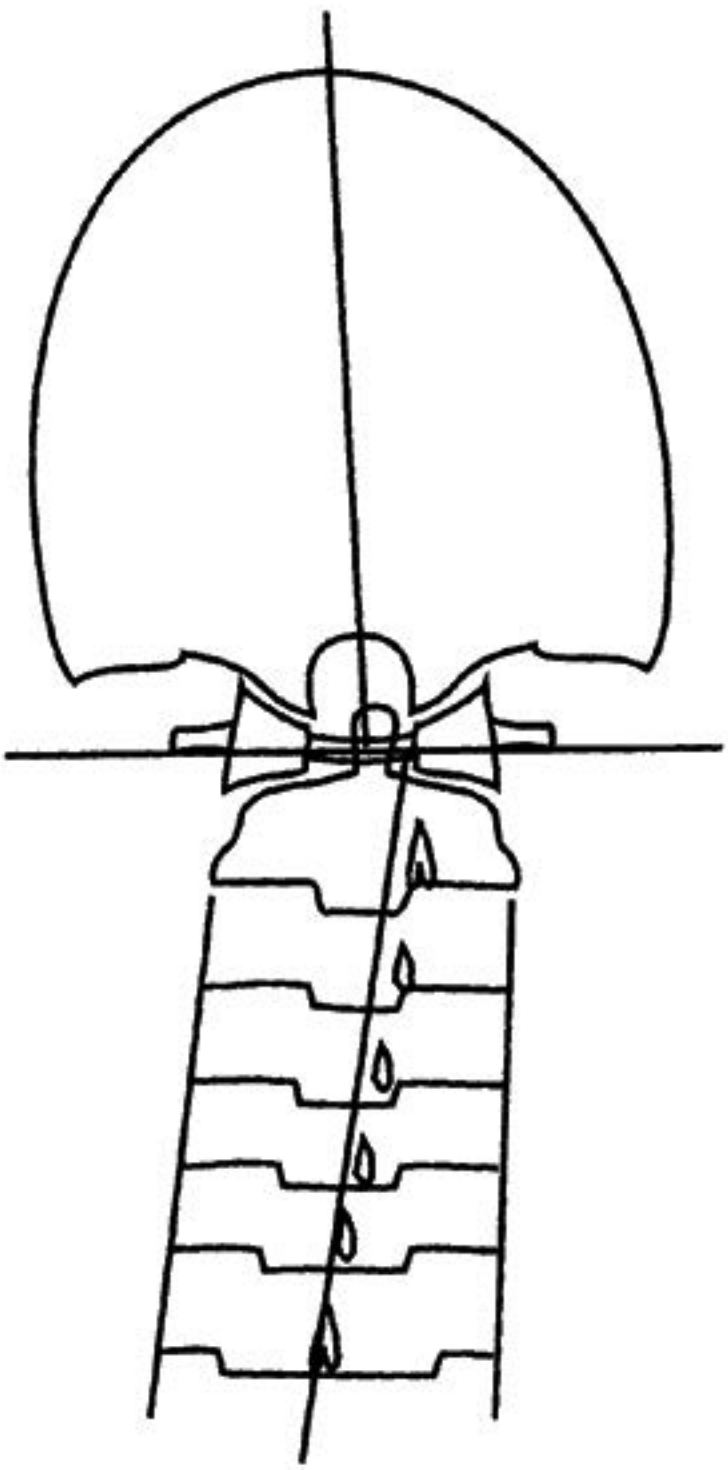

Figure 1.
Left *Into the Kink* misalignment with contralateral (superior) spinous.

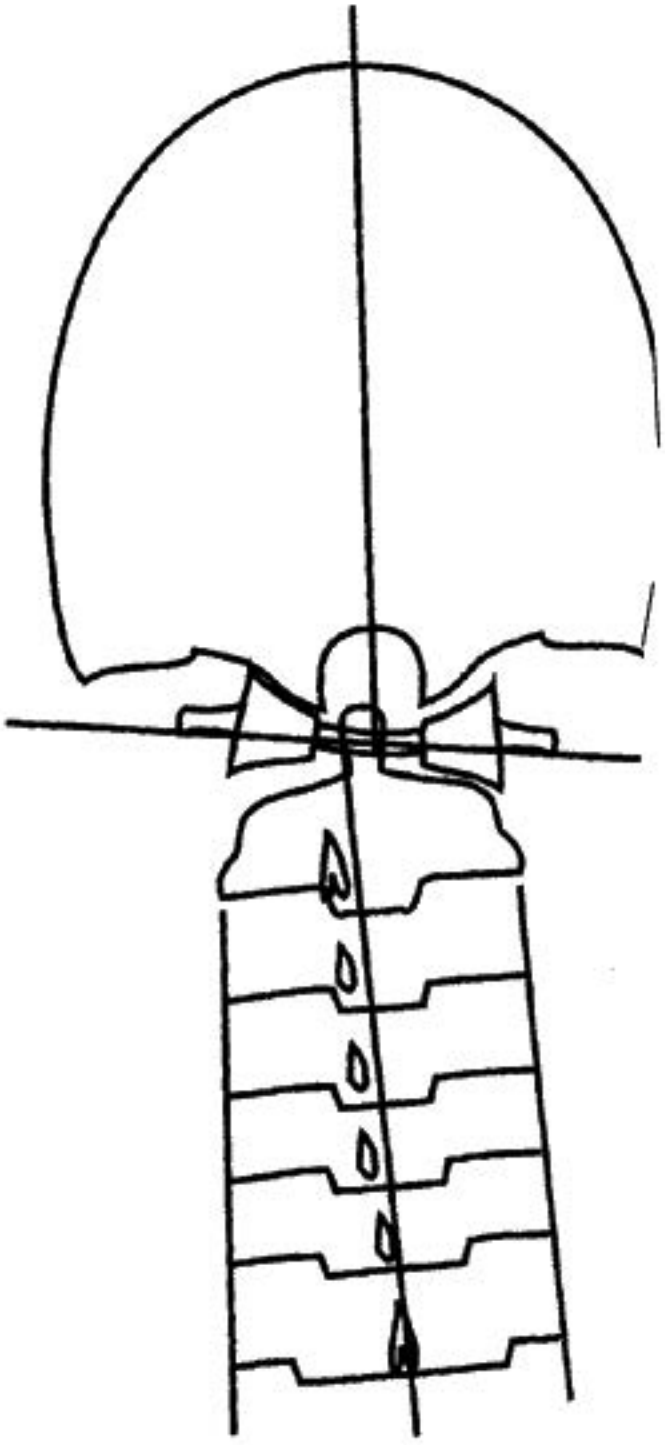

Figure 2.
Left *Opposite Angles* misalignmer with ipsilateral (inferior) spinous

The Grostic x-ray analysis procedure was used to analyze the radiographs for listing factors, including atlas laterality and rotation, lower angle and C2 spinous displacement. The x-ray listings were used to derive adjustment vectors for upper cervical care.

Supine Leg Check

The supine leg check was performed on each patient as dictated by following the Grostic Procedure. The patient was instructed to stand at the foot of the Grostic adjusting table, sit down on the end of the table and then slide back and lay down in a supine position. Each foot, with the shoe on, was grasped in the examiner's hands and positioned with slight headward pressure so that the soles of the shoes were in the same plane. The relative leg length difference was then viewed at the shoe/sole interface and estimated to the nearest 1/16 inch.

Activator Leg Checks

The following analysis was derived from the activator advanced manual (39) and verified by two activator instructors. The analysis involves carefully placing the patient prone on a hi-lo table, with their lower legs slightly flexed. The leg check is performed with the legs in two separate positions, one fully extended (Position #1) and one flexed to 90 degrees at the knee (Position #2). The Position #1 leg check is done by cupping the palms of the hands over the lateral malleoli and bringing the legs together until the heels touch and are perpendicular to the legs. The thumbs are then placed under the heel of each shoe, the index fingers posterior to the lateral malleoli, and the middle finger anterior to the lateral malleoli. The thumbs are used to take out any supination or inversion of the feet and a gentle constant headward pressure parallel to the tibias is applied. The side of the functional short leg (i.e. pelvic deficiency), if any, is observed by comparing the shoe-sole interface as a reference.

The relative leg length is also checked with the legs flexed 90 degrees at the knees (Position #2). In this position, the legs are held up in the flexed position and the doctor sights along the soles of the shoes to decide which leg is longer.

To assess the upper cervical spine, the Activator analysis provides a special "stress test" procedure, which involves having the patient flex their neck while the examiner checks the leg length difference. If a pelvic deficiency (PD) is observed in position #1 and crosses over in position #2, then it is considered positive for C1 laterality on the side of PD. If the leg does not cross over, then it is considered C2 spinous rotation to the side of PD (40). If C1 laterality is found, then C1 rotation is determined by having the patient turn their head to the side of PD. If the leg crosses over in position #2, C1 is considered posterior on that side. If the leg stays short in position #2, C1 is considered anterior on that side.

Another method for determining atlas rotation involves checking for balancing of the pelvic deficiency as the patient turns their head to one side or the other. For example, if the right PD leg balances when the head is turned to the right, then C1 is **anterior** on the right, if the right PD leg balances when the head turns to the left, then C1 is **posterior** on the right. While I am not certified in Activator Methods, many of the leg checks performed using the method were supervised by an associate in my office who is certified.

While the usual sequence followed in the Activator assessement is to check the knees, pelvis and lumbar spine first, I verified through personal communication with researchers at Activator Methods that the

cervical spine could be assessed independently.

It should also be noted that activator instructors recommend the use of a "challenge" to verify the correct adjustment listing. A challenge is performed by placing pressure on a vertebra in the direction that it is thought would cause a correction. It is hypothesized that if the challenge is correct, it will cause a temporary leveling of the leg length inequality. However, it is the opinion of the researchers at Activator Methods (in private communications) that the standard method described in the previous paragraph provides a more accurate assessment of atlas subluxation than the challenge method.

Posture Analysis

Posture analysis has been used historically to monitor patients' progress under chiropractic care, but it is also used by many chiropractors to determine how to adjust the upper cervical spine (41-43). The medical literature also contains discussions on the relationship between postural distortion, musculo-skeletal pain and overall health (44-45).

In posture analysis it is theorized that a high atlas plane line causes the head to tilt away from the side of laterality. It is also thought that the head will rotate in the same direction as the rotational misalignment, so that, for example, right head rotation would be a right posterior C1 or left anterior C1 and/or PL C2 spinous (right superior or left inferior spinous).

For this study, a special posture analysis board was used on all patients and a polaroid picture was usually taken to record any postural deviations. The posture analysis board, utilizing several horizontal lines and one center of gravity line, was accurately installed utilizing a plumb bob. Head tilt was also measured on the nasium x-ray.

Range of Motion

A general measure of cervical motion can be provided by measuring cervical range of motion (ROM). For this study, cervical range of motion was measured with inclinometers and/or an arthrodial protractor. A restricted cervical ROM was considered significant if there was a side-to-side asymmetry of five degrees or more. Based on cervical ROM, the side of atlas laterality should be on the side of restricted cervical lateral flexion. It is hypothesized that vertebrae can be locked in the direction they are misaligned and a restriction would occur in any attempt to move the vertebrae away from their fixated positions. For example, a right restricted cervical rotation ROM would accompany a right anterior C1 or left posterior C1 and/or a PR C2 (right inferior or left superior C2 spinous).

Static Palpation

Static palpation of the spine has been used in the analysis of vertebral subluxations since chiropractic's inception. Although it is generally considered to be a valuable part of most chiropractors' analysis, many researchers have criticized the reliability of palpation in determining vertebral misalignment (3,46). In this study, the examiner palpated for tenderness or swelling in the suboccipital muscles.

In Diversified technique, it is thought that the side of tenderness (i.e. muscle bundle) in the upper cervical spine represents a posterior atlas and/or body rotation of C2 on that same side. A positive palpatory finding at the C1-C2 region was considered significant when one side was predominantly more tender or swollen than the other side.

Thermography

Heat detecting instruments have been used since the 1930's to monitor patients' progress under upper cervical care (3, 47), and like the other analyses discussed in this paper, it has been found to be very valuable to many chiropractors. It is thought by some doctors of chiropractic, and one of my college instructors, that the side of atlas laterality will be found, in the great majority of cases, to have a colder temperature when using an infrared heat measuring instrument to test the C1 fossa areas. For this study, a non-contact single probe infrared thermography unit was used to measure the temperature of the left and right atlas fossa of each patient.

Factors Compared	N	Po%	Pe%	Kappa
Activator Atlas Laterality	166	53	58	-0.11
Activator C2 Spinous	108	49	51	-0.04
Activator Atlas Rotation	160	72	54	0.40
Head Tilt for Laterality (Kink)	122	93	58	0.84
Head Tilt for Laterality (Opp)	227	54	53	0.01
Head Tilt for Laterality (both)	349	67	55	0.28
Head Rotation for Atlas Rotation	216	50	51	-0.02
Head Rotation for C2 Spinous	135	54	51	0.06
Lateral Flexion for Laterality (Kink)	31	35	40	-0.07
Lateral Flexion for Laterality (Opp)	77	41	40	0.03
Cervical Rotation for Atlas Rotation	111	56	54	0.03
Cervical Rotation for C2 Spinous	83	66	53	0.28
Scanning Palpation for C1 Rotation	337	48	48	0.00
Scanning Palpation for C2 Rotation	231	44	49	-0.09
Low C1 Temp. for Laterality (Kink)	51	53	51	0.03
Low C1 Temp. For Laterality (Opp)	188	56	53	0.05
Short Leg for Laterality (Kink)	170	42	51	-0.17
Short Leg for Laterality (Opp)	468	54	53	0.00

Table 1.

Agreement and Kappa values for comparison of x-ray and non-x-ray methods of determining upper cervical misalignment. N is the number of patients who had data for both of the factors being compared, Po% is the percent of agreement observed and Pe% is the percent of agreement expected by chance, given the distribution of data.

DATA ANALYSIS

The patient database has a query function to help identify correlations between clinical findings. For this study, a series of queries was performed to specifically test each of the hypotheses under investigation. In each case, the x-ray analysis method would result in a Right or Left listing, or a rotation listing such as right anterior, right posterior, left anterior or left posterior. Similarly, the non-radiographic methods would provide a side of laterality or a rotation direction. During data analysis, the rotation listing was converted into either a clockwise (CW) or counter-clockwise (CCW) rotation for atlas or C2 by considering the transverse or spinous process movement associated with each direction of rotation. For instance, C1 rotation in the Grostic Procedure is listed with respect to the side of laterality, so a Right Anterior C1 would be the same direction of rotation (CCW) as a Left Posterior C1.

For each hypothesis, an agreement table was constructed, showing the number of times the two methods agreed on a finding, and when they disagreed. The Kappa statistic, which compares the percent agreement to the agreement expected by chance was calculated from the agreement table using a spreadsheet program.

RESULTS

The calculated percent agreement and Kappa statistic for each hypothesis are shown in Table 1.

In general, Kappa can range from -1 to 1. A value of 1 represents perfect agreement between two methods or examiners, while a -1 would exist if the two methods contradicted each other perfectly. A Kappa value of 0 shows that the percent agreement observed is equal to that obtained by just guessing at random (48). In this study Kappa ranged from -0.17 to 0.84. The best agreement, Kappa = 0.84, was observed between Head tilt measurement and the side of atlas laterality when a kink subluxation is present. The Activator check for atlas rotation showed a moderate agreement, Kappa = 0.40, with the x-ray analysis.

DISCUSSION

The data from this study shows that head tilt and the side of atlas laterality are well correlated only when a kink misalignment is present. If a particular patient presents with a head tilt and you know from past radiographs that a kink misalignment is typical for that patient, then you can assume that some degree of misalignment is present and needs to be adjusted.

None of the other comparisons carried out in this study showed much agreement at all. This is confusing in light of what is being taught in chiropractic colleges. It points to the general uncertainty of using any non-radiographic method to assess upper cervical misalignment patterns.

It is not unexpected that leg checks do not correlate well with the side of atlas laterality. Several aspects of the upper cervical misalignment pattern may play a part in producing spinal cord distortion and leg length inequality. For example, the NUCCRA organization has examined correlations and developed hypotheses in regards to the

functional short leg and different subluxation patterns (49). Although some valuable information has been obtained from these studies, no firm conclusions have been drawn. Dr. John D. Grostic performed a study of the relationship between upper cervical misalignment factors and leg check. Using an algorithm involving the upper angle, lower angle, axial and condylar circle diameters, C2 spinous and atlas rotation, he was able to predict the side of the functional short leg with 88% accuracy (28).

In an attempt to simplify patient assessment, some doctors have hypothesized that since most patients have an opposite angle subluxation, they will adjust the patient's atlas on the side opposite of the supine short leg. This method has been suggested for use with pediatric patients as well. An obvious question needs to be asked when using this logic. If x-rays are used to determine how to provide care or to decide if care is contraindicated for adults, then why would a doctor of chiropractic want to provide substandard care to a child whose nervous system is still developing? An analysis of the data in this study shows that leg length inequality is not an acceptable replacement for x-ray analysis.

Although it is up to the doctor of chiropractic to decide which analysis he/she will rely on, it appears that non-x-ray methods are not interchangeable with x-ray analysis. A possible explanation for this is that the upper cervical spine is a very complex area anatomically and neurologically. Because of the many misalignment patterns that may occur in the occipito-atlanto-axial area, it becomes very hard to make generalizations or to predict these multiple misalignments without measuring them. Lord Kelvin, one of England's most prominent physicists stated:

> When you can measure what you are talking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of a science (50).

It appears that true knowledge and understanding of the vertebral subluxation complex can only be achieved through quantitative analysis and characterization.

CONCLUSION

The data in this study reveals very poor agreement between x-ray and non-x-ray methods of determining upper cervical misalignment. These two types of patient assessments do not appear to be synonymous. While these results cast serious doubt on the comparative use of radiographic and non-radiographic methods, a firm conclusion cannot be drawn from this study because the data was derived from only one practice and the doctor in this study was not blinded during the patient assessments. On the other hand, the data was collected from a large number of patients over a long period of time and, even though the examiner was not blinded, data was collected before any plans had been made to perform statistical analysis.

From the author's standpoint, non-radiographic methods provide quick clinical checks that are valuable in monitoring patients pre- and post-adjustment, but should not be relied on for determining how to adjust the patient.

ACKNOWLEDGMENTS

The author would like to thank Jimmy Greer for his many months of hard work in developing the computerized database. Thanks also go out to Gregory Hovanic, D.C. for approving the activator analysis and proof reading this paper. Dr. Ed Owens was instrumental in editing the manuscript and helping with data analysis. Finally, love and thanks go out to the author's wife, Cynthia Eriksen, for patience, support and love.

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