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Validity of palpation of the C1 transverse process: comparison with a radiographic reference standard

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Objectives: *Primary goal: to determine the validity of C1 transverse process (TVP) palpation compared to an imaging reference standard.*

Methods: *Radiopaque markers were affixed to the skin at the putative location of the C1 TVPs in 21 participants receiving APOM radiographs. The radiographic vertical distances from the marker to the C1 TVP, mastoid process, and C2 TVP were evaluated to determine palpatory accuracy.*

Results: *Interexaminer agreement for radiometric analysis was "excellent." Stringent accuracy (marker placed ±4mm from the most lateral projection of the C1 TVP) = 57.1%; expansive accuracy (marker placed closer to contiguous structures) = 90.5%. Mean Absolute*

Objectifs : *But principal : Déterminer la validité de la palpation de l'apophyse transverse C1 par rapport à une référence d'imagerie normale.*

Méthodologie : *On a posé des marqueurs radio-opaques sur la peau à l'emplacement supposé de l'apophyse transverse C1 chez 21 participants recevant une radiographie APOM (bouche ouverte en incidence antéro-postérieure). Les distances verticales radiographiques entre le marqueur de l'apophyse transverse C1, l'apophyse mastoïde et l'apophyse transverse C2 ont été évaluées afin de déterminer la précision de la palpation.*

Résultats : *Les examinateurs se sont accordés pour dire que l'analyse radiométrique était « excellente ». Précision rigoureuse (marqueur placé à ± 4 mm de la projection la plus latérale de l'apophyse transverse C1) = 57,1 %; précision expansive (marqueur placé plus près des structures contiguës) = 90,5 %. Écart*

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Deviation (MAD) = 4.34 (3.65, 5.03) mm; root-mean-squared error = 5.40mm.

Conclusions: *Manual palpation of the C1 TVP can be very accurate and likely to direct a manual therapist or other health professional to the intended diagnostic or therapeutic target. This work is relevant to manual therapists, anesthetists, surgeons, and other health professionals.*

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KEY WORDS: palpation, C1 TVP, radiograph, validity, chiropractic

absolu moyen (EAM) = 4,34 (3,65, 5,03) mm; valeur quadratique moyenne d'erreur = 5,40 mm.

Conclusions : *La palpation manuelle de l'apophyse transverse C1 peut être très précise et présente de fortes chances de guider un thérapeute manuel ou un autre professionnel de la santé vers le diagnostic ou la cible thérapeutique souhaités. Ce travail concerne les thérapeutes manuels, anesthésistes, chirurgiens et autres professionnels de la santé.*

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MOTS CLÉS : palpation, apophyse transverse C1, radiographie, validité, chiropratique

Introduction

Manual therapists often assess bony landmarks for asymmetry and for misalignment as part of their assessment of the musculoskeletal system.[1,2] A spinal motion segment that is found both fixated and misaligned is generally considered a potential site of care, especially if symptomatic.[3] To be considered clinically useful, the examination methods used to identify symmetry or misalignment must be found both reproducible and accurate. The accuracy of spinal static palpation has been addressed by validity studies that compared its results with an imaging reference standard. In each of these studies, palpators placed a radiopaque marker, either lead or fish oil, on the putative location of a spinal landmark, which was subsequently measured in relation to the actual location of the landmark as established by an imaging procedure: plain radiography[4-10], ultrasound imaging[11], fluoroscopy[10], or magnetic resonance imaging[12,13].

The accuracy of palpating lumbar spinous processes (SPs) was addressed by Broadbent et al[12], Furness et al[11], Harlick et al[4], Ebraheim et al[5], Merz et al[6], Robinson et al[7], and Snider et al[8]. The accuracy in the thoracic spine was studied by Cooperstein et al[9] and Holmaas et al[13]; and in the cervical spine by Robinson et al[7] and Shin et al[10]. Apparently, only 1 study, that of Jende et al[14], addressed palpation of spinal TVPs rather than SPs. These latter investigators studied whether examiners could accurately identify lateral translation of C1 in the frontal plane. The present authors are unaware of any studies that addressed the accuracy of C1 TVP palpation in relation to its contiguous structures, the mastoid process and the transverse process (TVP) of C2.

This study sought to determine if static palpation of the C1 TVPs were accurate compared with radiographic analysis. If so, more credence would be afforded to manual therapy interventions putatively directed at C1. On the other hand, lacking demonstration of such palpatory specificity, mechanical diagnoses and claims made for interventions directed at C1 would seem over-reaching. The results of this study would clarify whether an intervention directed at C1, with its unique anatomy, may result in different clinical outcomes from those of other cervical interventions, as some have claimed.[15]

There are several threats to the accuracy of upper cervical palpation inherent to the special anatomy of this spinal region. Although cervical SPs only rarely overlap, as in Baastrup's disease[16,17], there is some evidence that the mastoid process occasionally overlaps the C1 as seen on an anterior-to-posterior open mouth (APOM) radiograph[18]. This would almost certainly complicate distinguishing the adjacent structures. As another potentially confounding issue, craniocervical anomalies are found in 1-4% of the population. Possible anomalies include elongated mastoid processes, lateral ponticles, and ossification of the stylohyoid ligament.[19-22] Dysplasia of the upper cervical spine has been well documented.[23-27] Since the present study was conducted within the venue of a chiropractic college, it may be relevant that congenital anom-

alies among chiropractic students have been reported to be higher than in the general population.[28,29]

The primary purpose of the present study was to determine the accuracy of static palpation of the C1 TVP, in order to secondarily establish the feasibility of directing interventions specific to the C1 vertebra, in both clinical and research settings.

Methods

The investigators recruited a convenience sample of 21 chiropractic students who were scheduled to receive radiographic examination at the chiropractic college clinic. Their x-ray examinations had been ordered prior to and independently of the goals of the research project. Since the authors were performing a secondary analysis of radiographs taken for a different purpose, no participant was exposed to additional radiation as a result of their having being involved in this project. The Institutional Review Board of the chiropractic college approved the study, and each participant was provided with an explanation of the procedures and an opportunity to ask questions before providing signed informed consent.

The only deviation from the usual radiographic procedure was that prior to exposure, a palpator putatively identified the C1 TVP bilaterally, and affixed to the participant's skin a 2mm in diameter radiopaque lead marker mounted on a self-adhesive pad ("nipple artifacts markers", AliMed.com). Following that, APOM and sagittal plane radiographs were obtained as part of the college clinic's typical full spine series, utilizing proper filtration and collimation as per its standard protocols.

Of the 21 subjects seen in this study, 19 were palpated by the Principal Investigator (PI), a chiropractor with 8 years of experience, and two by another chiropractor with over 2 years experience. The participant was seated in a neutral posture. The palpator stood behind the seated patient and used the tip of the index finger to locate the C1 TVP by finding the angle of the mandible, sliding slightly superior and posterior to the mandibular ramus while remaining anterior and inferior to the mastoid process. The distance from the mandibular ramus to the mastoid process is typically about one finger's breadth and the C1 TVP is judged to be the bony prominence that lies between these two bony landmarks.[30-35] An effort was made to remain perpendicular to the surface of the participant's skin, irrespective of any postural asymmetry. Having contacted the skin lateral to the projection of the C1 TVP, the palpator placed the radiopaque marker directly overlying the most lateral projection of the C1 TVP, avoiding as much as possible soft tissue slippage during the process.

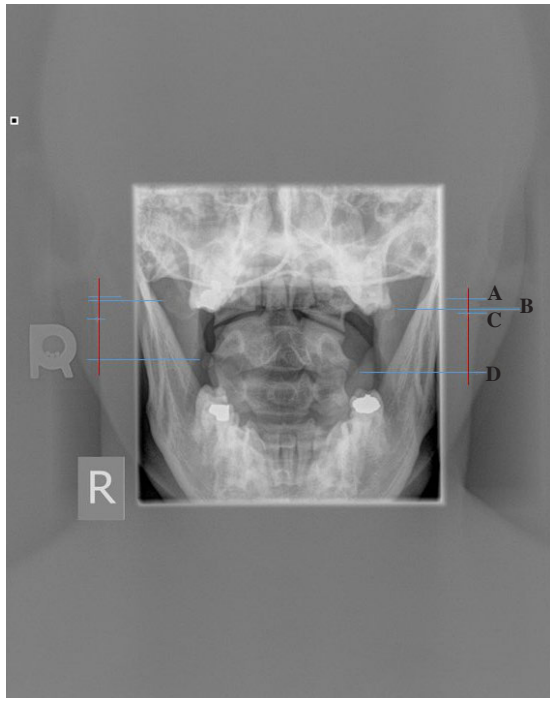

Figure 1. Radiometric method
True horizontal lines A, B, C, and D demarcate the inferior mastoid, C1 TVP, marker, and C2 TVP, respectively. The red vertical lines pass through the markers. Line B-C is examiner error for C1 TVP palpation, line A-C is maker-mastoid distance, and line D-C is C2 TVP–marker distance. In this exemplar radiograph, the right mastoid process and the upper surface of the left C1 TVP are difficult to visualize.

All patient information was removed from the digital image that was provided to 2 of the investigators for the purpose of radiometric analysis. They analyzed the radiographs well after data collection was complete (several months in one case and more than a year in the case of the other). The radiographs were analyzed digitally (Figure 1) using the GIMP 2.8 software product (http://www.gimp.org/). This software measures the vertical, horizontal, and direct distances in pixels between any 2 points identified on a graphic image. Measurements were obtained on the left and right for each of 21 partici-

pants (thus 42 measurements in all) for the vertical distance of the marker from the most lateral portion of the C1 TVP, the inferior aspect of the mastoid process, and the most lateral aspect of the C2 TVP. The left and right horizontal distances from the skin to the marker were also measured in a randomly selected subset of 10 participants. To convert the pixel measurements to millimeters (mm), the average width in pixels was considered equivalent to the average width of a C1 vertebra (as measured between the most lateral aspects of the TVPs), which has been established to be 73.5mm.[36,37] This conversion protocol was double-checked for accuracy by determining how many pixels corresponded to the known 2mm diameter of the radiopaque markers that were used. The radiometric method is illustrated in Figure 1.

Statistical analyses were performed in SPSS v.19 (http://www-01.ibm.com/software/analytics/spss/). Intraclass correlation coefficients (2,1) were calculated for the 2 investigators who measured the distances from the markers to the osseous landmarks. Both the MAD (Mean Absolute Deviation), the average of the absolute values of examiner errors for the vertical marker-TVP measurement, and the RMSE, root mean squared error (another measure of examiner accuracy) were calculated. A Pearson product-moment correlation coefficient was obtained to determine if there were correlation between examiner errors on the left and right.

Accuracy was calculated according to both stringent and expansive definitions of accuracy. To calculate accuracy stringently, the center of the marker was considered in relation to the *field* of the C1 TVP, the interval between the superior and inferior surfaces of the C1 TVP. Since these surfaces could not be consistently visualized, and in some cases displayed considerably irregular contours, the investigators found it more feasible to identify and measure from the most lateral projection of the TVP. Since this most lateral projection of the TVP was approximately centered between the superior and inferior surfaces of the TVPs, this method was mathematically equivalent to having measured from the midpoint of the field of the TVP. Knowing from previous studies that the average frontal plane width of the C1 TVP is approximately 8mm[18], the marker center was stringently considered to lie within the field of the TVP when it was ±4mm from most lateral projection of the TVP. To calculate accuracy *expansively*, the palpator was judged to have been accurate when the center of the marker was placed closer to the most lateral aspect of the C1 TVP than to either the inferior aspect of the mastoid process or the most lateral aspect of the C2 TVP.

Table 1.
Accuracy as measured by MAD

	Mean absolute difference	MAD 95% confidence interval (CI)		Standard error of mean	σ_e, root mean squared error
	MAD, mm	lower	upper	SEM	RMSE, mm
left	4.76	3.03	6.49	0.88	6.21
right	3.92	3.00	4.83	0.47	4.45
grand	4.34	3.65	5.03	0.35	5.40

Table 2.
Accuracy as measured by % agreement

	Left		Right		Grand
Stringent accuracy	54.7%		59.5%		57.1%
	Mastoid	C2 TVP	Mastoid	C2 TVP	
Expansive accuracy	100%	92.9%	97.6%	100%	90.5%

Results

Twenty-one minimally symptomatic participants were recruited (60 percent male, mean age 26) and palpated bilaterally, resulting in a total of 42 measurements of the vertical distance between the centers of the radiopaque marker and the most lateral aspect of the C1 TVP. The intraclass correlations (ICCs) for the 2 investigators marking the radiographs were 0.92 for the C1 TVP distance-to-marker, 0.82 for the mastoid distance-to-marker, and 0.84 for the C2 TVP distance-to marker. All of these ICC values were judged "excellent" according to the Landis & Koch interpretive scale.[38]

Tables 1 and 2 summarize accuracy in this study in terms of both MAD and % agreement, respectively. MAD, the mean absolute value for examiner marker-TVP errors, was 4.76, 95% CI [3.03, 6.49] mm on the left; and 3.92, 95% CI [(3.00-4.83]) mm on the right, resulting in a grand MAD of 4.34 (3.65, 5.03) mm. The square root of mean squared error (MSE) yields root-mean-square-error (RMSE), yet another measure of examiner accuracy. In this study, left RMSE was 6.21mm, and right RMSE

4.45mm, resulting in a grand RMSE of 5.40mm. RMSE will always be larger or equal to the MAD. The greater the variance in examiner errors, the greater the difference between them. In fact, when RMSE=MAD, all the errors are of the same magnitude. Since grand RMSE exceeded grand MAD by only 1.06mm, examiner errors were confirmed to be relatively small. The average distance of the marker to the mastoid process was 8.70mm, and to the C2 TVP midpoint was 13.77mm.

Stringent accuracy, defined as when the marker center was ±4mm from the average center of the TVP field, was achieved in 24 of 42 (57.1%) measurements, 54.7% on the left and 59.5% on the right. Expansive accuracy, when the marker was closer to the C1 TVP than to either of the contiguous structures, occurred in 38/42 (90.5%) cases; the marker was closer to the left C2 TVP in 3 cases (by an average of 2.99mm), and to the right mastoid in 1 case (by 3.39mm). There were no significant differences in accuracy when the data were stratified by gender.

To determine if the palpator errors on the left and right were correlated, the authors obtained their Pearson's product moment correlation value for their signed values: r= 0.63 (two tailed p=.001). On average, the left marker was positioned 1.07mm inferior to the C1 TVP, and the right marker 0.57mm inferior, for a mean inferiority (representing systematic bias) of 0.82mm. A set of 10 cases was randomly selected to determine if the depth of the C1 TVP as measured to the marker were related to the accuracy of C1 TVP palpation. There were no clinically or statistically significant relationships.

Discussion

A 2003 review article[39] stated there had been relatively few studies of the validity of spinal palpatory examination procedures but the number has been growing. Lack of consistency in the use of indexing terms may have complicated the process of retrieving relevant literature.[40] Authors investigating the validity of spinal landmark palpation as compared with an imaging reference standard have used varying definitions of accuracy, some including both strict and more liberal, clinically relevant definitions; comparable to the "stringent" and "expansive" definitions in the present study. As a general rule, prior studies have defined a posteriorward projection of a SP or an intervertebral interspace to be its "field," and then scored the radiopaque marker as being strictly within or more permissively overlapping this field. This strict definition of accuracy may be anatomically accurate, but may not be clinically relevant. The vertebra in question articulates with segments above and below, so that diagnostic procedures and therapeutic interventions necessarily involve to some degree at least 2 motion segments involving 3 contiguous structures. Taking this into account, placing the radiopaque marker somewhat outside the field of the SP would not likely undermine the purpose of the diagnostic or therapeutic procedure, so long as it were closer to the target than to adjacent structures. Recognizing this point of view, some of the prior studies defined a more liberal concept of accuracy. In some cases the marker was judged accurately placed when closer to the target than adjacent structures[13,41,42], and in others by defining the field of accuracy to include ±1 level[4,11]. The following brief review of the published literature is organized by the profession of origin: manual therapy, anesthesiology, or surgery.

Manual therapy studies

Like the present authors, Jende et al[14], studied the accuracy of C1 TVP palpation, but with a very different study goal: to determine the accuracy in identifying frontal plane lateral deviation. Accuracy was poor. Robinson et al[7] determined the accuracy of numerating the C7 and L5 SPs using methods commonly used by physiotherapists. The mean expanded accuracy for 2 manual therapists was 64% for C7 and 42% for L5. Merz et al[6] studied whether the addition of visual cues as to the location of anatomical landmarks in the pelvis would increase the accuracy of motion palpation in identifying the location of the SP of L5. The accuracy increased from 45% to 83%. In Snider et al[8], a number of examiners attempt to identify the SP of L1-4 using a number of spinopelvic landmarks as reference points. Using a posteroanterior radiograph reference standard, rather than the more typical sagittal plane radiography, the accuracy was 69%. Cooperstein et al[42] had a palpator place radiopaque markers on the thoracic SPs palpated to correspond with the inferior tip of the scapula, and also the 2 SPs judged to be 3 spinal levels inferior and superior. Expanded accuracy, in which the marked level was closer to the intended level than to contiguous structures, was 76.5%. Harlick et al[4] allowed physiotherapists to use whatever technique they preferred to identify the SPs of L1, L3, and L5. Accuracy, defined as any degree

of overlap between a radiopaque marker and the field of the SP, was 47%; whereas expanded accuracy, including 1 spinal level above or below, was 88%. Using relatively large 7.5mm in diameter radiopaque markers resulted in a relatively permissive definition of accuracy, since this increased the likelihood of a marker overlapping the field of the intended SP. Three studies[43-45] investigated whether the PSISs and an intercrestal line could reliably identify a lumbar level as confirmed by a radiopaque marker, but since the examiners did not actually palpate the spine, their work will not be reviewing herein.

Anesthesiology studies

Anesthetists share the need with manual therapists to accurately identify the correct intervertebral interspaces, using palpation to identify a suitable vertebral level for epidural and spinal anesthesia. Broadbent et al[12] studied the accuracy of placing a fish oil marker at any of the lumbar vertebral interspaces. Their accuracy rate was 29% as established by magnetic resonance imaging. Furness et al used similar methods to determine the accuracy of identifying the L2-3, L3-4, and L4-5 interspaces. Accuracy, defined as marker placement within the field of the interspace was 30%, compared to the 71% accuracy achieved using ultrasound imaging. Holmaas et al[13], using a magnetic resonance imaging reference standard, determined the accuracy of numerating vertebral levels from the T7-8 to the T11-12 interspace by counting either cephalad from the putative L3-4 level at Tuffier's line (drawn across the iliac crests), or caudally from the putative C7 level (thought to be the vertebra prominens). Palpation was judged accurate when a fish oil capsule marker was either placed the correct intervertebral space, in 26.7% of cases; or more expansively when it overlaid an adjacent SP, in 36.7% of cases. Shin et al[10] compared the accuracy of two assessment procedures for identify the C7 SP: considering C7 to be have the most prominent cervical SP, and using motion palpation into extension. Using fluoroscopy as a reference standard, the motion palpation method was 77.1% accurate, compared with 47.9% using the most prominent SP method.

Surgical studies

The surgical community is also confronted with the same necessity to accurately identify the location of C1, which serves as an anatomical landmark for surgeries and treating various otolaryngeal conditions, including injuries to the spinal accessory nerve.[46-48] In a study by Sheen et al[47], although there was some clinical disagreement on numerating the vertebra, a CT scan and computer modeling determined the most prominent TVP identified by manual palpation was in fact the C1 TVP. In a lumbosacral study involving surgical protocols[5], surgeons placed a radiopaque marker directly on the TVP cephalad to a spinal segment that was to be surgically fused A sagittal plane radiograph then determined if the desired fusion level was in fact the spinal level that had been fused. The accuracy rate was 76/80 (95%), deemed unacceptable, with 4 patients in the study having had the wrong surgical level fused.

Operational definition of accuracy in the present study

In the present study, accuracy was calculated in both a stringent and a more permissive manner. According to the strict definition, a palpator would place a soft-tissue marker within the 8mm wide field of the C1 TVP; whereas according to the more clinically relevant expansive definition, the palpator would place the marker closer to the C1 TVP than to either the mastoid process above or the C2 TVP below. Unlike all but one of the spinal landmark validity studies reviewed, our study involved TVP rather than SP palpation. The only other study to have done so was Jende et al[14], who found palpation to have been inaccurate. Due to factors related to image interpretation, it would have been difficult to define a field of marker accuracy by projecting lines from the inferior and superior aspects of TVPs, analogous to what investigators had done in the reviewed SP studies. As an alternative method, the authors identified the most lateral projection of the C1 TVP on the radiograph, which moreover would have presumably been the most likely aspect of the vertebra with which the palpator had "made contact" through the soft tissue.

Our method of calculating expanded accuracy, wherein the marker was closer to the target than to contiguous structures, necessarily differed in method from some of the SP validity studies that also included a concept of liberal accuracy.[4,11,13,41,42] In these other studies the contiguous structures were equally distant from the targeted structure; whereas in the present study, the mastoid-C1 TVP distance did not equal to the C1 to C2 TVP distance. Since the average distance of marker to mastoid was

8.70mm, and to C2 TVP midpoint 13.77mm, there was no way to define a *constant magnitude* of examiner error that would be regarded as expansively accurate. Therefore, the authors defined expanded accuracy in a purely clinical sense as having placed the center of the radiopaque marker closer to either of the contiguous structures (mastoid process and C2 TVP).

The other studies on the accuracy of SP palpation used markers ranging in size from the 2mm lead markers similar to those used in our study to 8-10mm fish oil capsules[12,13]; some studies did not specify the dimensions. If the definition of accuracy includes overlap of a spinal landmark with a radiopaque marker, then the accuracy rate will be directly proportional to the side of the marker. Since the present study used relatively small markers, the results would have understated its accuracy compared with studies using larger markers that defined agreement as *any degree of overlap* with the spinal structure, (e.g.,[4]). As an alternative, the present study defined stringent accuracy as a marker's center having been ±4mm from the center of the C1 TVP, given its average height of 8mm.[18] Although the calculated MAD values do represent examiner error in this study, the term "error" could be misleading. In fact, 57.1% of these "errors" actually overlapped the TVP; that is, they were not errors at all in the normal sense of the term, when used outside the context of statistical analysis. Only when the palpator error exceeded 4.0mm (42.9% of cases) could it be inferred there had been *any* palpatory error, since the C1 TVP is a surface with a vertical height rather than constituting a point.

In this study the mean of signed examiner errors was 0.82mm, signifying a slight bias toward identifying the TVP inferior to its actually location. This may have been due to the fact that the palpatory method involved making contact with the putative C1 TVP from an inferiorward direction. This very small distance is unlikely to be clinically relevant. The very rationale for calculating the MAD statistic lies in the fact that a simple average of positive and negative examiner errors converges toward zero when bias is small, since positive and negative values tend to offset. Failure to appreciate this can and has led some authors to report exaggerated agreement for examination methods or examiners. To obtain a more clinically relevant measure of average examiner errors, it is more instructive to look at the mean of the *absolute values* of the errors, the Mean Average Deviation (MAD). MAD is a robust measure of the measurement errors, defined as such because it is more resilient to outliers in a dataset than calculations of standard deviation, which square measurement errors. In this study, the MAD and MSE were greater on the left, suggesting more palpatory accuracy on the right. MAD equals RMSE when all the errors are of the same magnitude. With increasing variance in the errors, RMSE increases in relation to MAD, and thus becomes a more useful (certainly more conservative) estimate of accuracy. The significant correlation of examiner errors on the left and right suggests there were symmetric anatomic features of the C1 vertebra that predisposed toward the direction and magnitude of examiner error.

Triano *et al* performed the most comprehensive study of its kind on the reliability and validity of the various methods used by manual therapists to target the site of care.[3] The evidentiary support for the use of static palpation to determine a spinal site of care was judged to be "unclear." (Some[4,14] but not all of the studies reviewed in the current article were included in the site of care article.) Several studies have called into question a manual therapist's ability to deliver forces to their intended targets.[49-56] It is not known to what extent diagnostic and/or adjustive imprecision in the manual therapy professions leads to suboptimal clinical consequences. There is some evidence suggesting that under certain circumstances the information provided by cervical motion palpation for the specific site of care may not change the outcome of care.[57]

In the practice of manual therapy, misdiagnosing the level of a misaligned or dysfunctional segment may or may not result in an altered clinical outcome. For example, an intervention might nonetheless be directed at an appropriate level, even though the clinician may have misidentified it. Although this misidentification need not directly lead to a clinical problem, issues may arise if or when another or the same clinician attempts to intervene on the incorrectly charted level on another day. Level misidentification may also be problematic in attempting to track clinical changes over time. Accurate palpation is crucial when the practitioner is attempting to correlate physical examination findings with the results of an imaging study, in order to decide upon the clinical relevance of manual examination findings. In addition to the context of static spinal palpation, accuracy in identifying spinal levels has also manifested as an issue in the context of motion palpation, where sometimes the palpators have agreed on the

locations of dysfunction, but disagreed on numerating the level.[58-61] Comparable to the expanded definitions of accuracy utilized in some of the SP validity studies, some of the motion palpation studies have also expanded the field of examiner agreement to include nominated segments that were within one level of each other.[62,63]

Limitations of the study

It was deemed challenging to place the radiopaque markers where intended. Despite attempts to limit skin movement, the confined space behind the ear required the palpator to remove the finger from the suspected C1 TVP position to place the radiopaque marker, and then re-palpate through the radiopaque marker to ensure accurate placement. Lateral tilting of the head in relation to the floor might have altered marker positioning relative to the C1 TVPs; on the other hand this would have confounded the results of this study only if had participants assumed a different degree of lateral titling during the radiological examination. Since 1 of the palpators also performed radiometric analysis, it might have been possible for him to identify or recall specific palpatory findings that might have biased subsequent analysis of the radiographs. That stated, he felt that so much time had elapsed between obtaining and analyzing the radiographs that this was virtually impossible. Although the study results showed stringent accuracy of 57.1% and expansive accuracy of 90.5% in palpating the C1 TVP, it did not address the interexaminer reliability of the procedure. Even if demonstrably valid, without demonstrated interexaminer reliability the described palpatory procedure would not be judged clinically useful. The evidence is sparse that a specific adjustment of C1, or any vertebral site of care for that matter, achieves a clinical outcome that is different or better than what might have been achieved by adjusting a different level.[3,57,64] The participants in the study were almost all young adults, all either asymptomatic or minimally symptomatic (pain <3 on a 0-10 pain scale). This homogeneous participant group differs from patients that would be drawn from the general population, thus requiring caution in projecting these results to more heterogeneous patient populations.

Conclusions

The primary purpose of the present study was to determine the accuracy of static palpation of the C1 TVP, in order to secondarily establish the feasibility of directing interventions specific to the C1 vertebra, in both clinical and research settings. The results suggest examiners can to some degree accurately identify the C1 TVP on a patient. Although ideally speaking this determination should best me made for all spinal levels, it might be considered especially important for the C1 level given the abundance of claims made for its unique clinical importance.[15]

The authors were fortunate in being able to harvest information from radiographs being taken for clinical reasons unrelated to the study goals, thus not requiring participants to be exposed to additional ionizing radiation. Other investigators interested in pursuing similar research goals, but not having a similar capability of harvesting such information, might consider using ultrasonography, as did Furness et al[11] or magnetic resonance imaging, as did Broadbent et al[12] and Holmaas et al[13].

This finding should be of interest not only to manual therapists, but also a variety of other health professionals, including nurses, surgeons, anesthesiologists, and acupuncturists. This study does not by itself establish the clinical utility of this procedure, but does establish a methodological foundation for devising clinical outcome studies that could in principle do so. Future studies on the hypothetical importance of optimizing a specific site of care ultimately will require more studies such as the present one.

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