A review of considerations regarding audible articular cavitation:

Part 3 of a series.

Peter Rome and John Waterhouse

Abstract: The biomechanical release of the articular fixation element of a vertebral subluxation is often signified by an audible cavitation. While some minor cavitation may occur with non-specific forms of finger manipulation, it has been shown that a manual adjustment results in audible cavitation which can activate sensory and autonomic reflexes. However, more recent research indicates that the audible cracking sound is not related to the collapse of intra-articular gas bubble. This review discusses aspects of the articular audible cavitation of the previously researched metacarpophalangeal (MCP) joints under distraction, as compared to cavitation of a vertebral facet fixation noted during a segmental adjustment. It is suggested that these procedures may be quite different mechanisms. The mechanism of the origin of audible cavitation has been the subject of a range of theories over the years. Its timing in relation to a gas cavitation and separation of facet joint surfaces is still subject to clarification following recent research. Due to technological constraints, the speed of the audible release and the cavity formation, the specific timing has yet to be conclusively demonstrated. Future research may focus on suction separation of the facet interface, and particularly of vertebral facets in preference to research done with metacarpophalangeal articulations.

Indexing terms: Cavitation, Audible cavitation, Articular release.

Introduction

The cracking sound of joint cavitation has been generally adopted to indicate the audible release of certain diarthrodial articulations, typically with spinal articular manipulation or finger joints.

For some five decades it was widely accepted that the cracking sound of joint distraction and facet manipulation was due to the collapse of the intra-articular bubble. (1) Evidence has been produced which contradicts that assumption and indicates that the sound is produced at the inception of the bubble, and the bubble still exists after the audible *crack*. (2, 3, 4)

> *... when clinically associated with these signs and symptoms, cavitation demonstrates that a pre-existing fixated articulation has been subsequently released.'*

The term *audible cavitation* is preferred by us to identify instances of what was once thought to be intra-articular cavitation collapse. Both terms are somewhat misleading and effectively misnomers. This emphasises the call for a more appropriate term once the definite origin of the crack sound is determined.

It is thought to be too late now to supplant *cavitation* despite it being the opposite of the definition for a *bubble collapse*. Until such time as a replacement term is found, we adopt here the term *audible cavitation*.

An ambiguity has been created in assuming the bubble collapses with the sound when it is not the collapse that generates the sound. A new term would be appropriate. One option could be from Old English *cracian* being '*make a sharp noise, give forth a loud, abrupt sound*.' (5)

Brodeur suggests that the audible aspect is formed by the decreased intra-articular pressure of synovial fluid causing dissolved gases to be released forming a cavitation bubble and the audible element is facilitated by an elastic recoil of the capsule. (6)

More recent evidence now indicates that the bubble still exists after the audible cavitation has taken place. (2, 3) While theories persist as to the actual mechanism of the sound, Fryer proposes further research to clarify this phenomenon. (4)

The gases contained in the bubble makes up 15% of synovial fluid and consist of 80% carbon dioxide, with oxygen and nitrogen comprising the other 20%. (6) For comparison, it is noted that the gas (radiolucency or 'vacuum phenomenon') in degenerating intervertebral discs is reported to be 90%-95% nitrogen. (7, 8) The cavitation bubbles in synovial fluid and other biofluids are generated out of the dissolved gas within the liquid. (9)

Complex research in recent years still has not definitively identified at what stage the cavitation sound occurs – before, during, or after bubble inception, but before and separate to bubble collapse. (3) Kawchuk et al confirm that the cracking takes place in association around the time of cavitation inception rather than with the collapse of the existing bubble, although it has been demonstrated that the bubble still exists after the audible 'pop'. (2)

In relation to joint manipulation, the term *cavitation* has been associated with both the creation of a bubble in the synovial fluid and the collapse of that bubble with associated sound. It has been confirmed that the sound is not a result of the bubble collapse.

The relationship of the bubble cavitation with spinal or indeed articular adjustments is that it signifies the release of the functionally fixated joint involved. It is noted however, that cavitation may also be elicited in joints that are not subluxated, as in the audible cavitation of the knuckle joints.

When associated with clinical signs and symptoms, joints that exhibit hypomobility with or without displacement meet the criteria for functional correction and may be designated as a subluxation. In chiropractic, that correction is designated an adjustment. When clinically associated with these signs and symptoms, cavitation demonstrates that a pre-existing fixated articulation has been subsequently released.

Following the extensive but inconclusive experimentation conducted by Fryer and colleagues reported in 2017. Fryer states that in one of their experiments (Model A dry joint) that the audible cavitation occurred '*with further traction and detachment of the cup.*' (4) This may suggest that one theory of the cracking sound may be attributed to the sudden mechanical separation of the *suction cup* from its paired lubricated synovial articular surface. The continued research by those authors in forthcoming experiments should provide greater elucidation on the topic. (3, 4)

Differences may also exist between the audible cavitation of vertebral facets during manipulation, and that of MCP and interphalangeal joints. This comparison raises questions as to whether these two articulations are identical enough to draw conclusive comparisons. (10)

Be it a placebo effect or not as some claim, the cavitation sound associated with a vertebral adjustments can be reassuring to the patient, and to the practitioner, especially when it is associated with an appreciable attenuation of symptoms. (11)

Historical

There have been a plethora of theories and terms broadly considered in relation to the cavitation - the 'popping'or 'crack' sound made by some joints with self-movement or assisted movement. They include:-

1939	Tightening of the fibrous capsule (12)
1947	Articular release when adjusted (13)
	A clear space appears in the radiograph (13)
	Partial vacuum with water vapour and blood gases (13)
	Vibration of tissues (13)
	'*Not the breaking of the adhesive film between the articular surfaces*' (13)
1971	'*Vapour*' bubble collapse. (14)
	'*The bubble is not the cause but the effect of the crack*' (14)
1994	Release of synovial fold (plica) (15)
	Articular or periarticular adhesions (15, 16)
	Unbuckling of motion (15, 16)
	Release of entrapped synovial folds (15,16)
	Sudden stretching of hypertonic muscles (15, 16)
1995	Elastic recoil of capsule (6)
	Pressure reduction within the joint (17)
2000	Sonoluminescence (18, 19)
2001	Tendons and ligaments (17)
	Sound caused by '*gas coming out of solution*'. (17)
	Capsule snap/elastic recoil. (20)
2002	Trapped meniscoids (21)
2003	Mechanotransduction (22,23)
	Mechanobiology (22)
2005	Rapid distention of the facet joint surfaces (24)
2010	Reflexogenic muscular response (25)
2015	Bubble *formation* (2)
2017	Stretch or compression of joint capsule
	Shifting tendons (26)
	Ligaments shifting too fast (26)
	Snapping tendon (26)
2020	Piezo electric effect (27, 28, 29, 30, 31)

Cavitation

The literal definition of cavitation is the creation of a cavity and relates directly here to a bubble in a liquid. (32) It has taken on additional meaning as the audible collapse of that bubble – and audible cavitation. Unsworth states that '*Cavitation is the term used to describe the formation of vapour and gas bubbles within fluid through local reduction in pressure*.' (14)

However, as the term *cavitation* has been long-associated with the cracking of joints undergoing manipulation as in casual finger cracking, it is modified at this time as *audible cavitation*.

The radiolucent bubble is formed by the extraction of dissolved gas from synovial fluid during separation of facet surfaces from resultant negative pressure. The nucleation of nano-bubbles merge with micro-bubbles to form the larger readily identifiable single *cavity*. After the collapse of the bubble, the gas reabsorbs back into the synovial fluid. (33, 34, 35, 36, 37)

Determining the timing of the bubble inception in relation to an audible cavitation has been technically difficult as it is limited due to the instrument technology used, and the speed of the phenomenon. (3) The frames per second of cineroentgenography (120 fps, MRI 3.2 fps), is below the 1200 fps needed to isolate the speed dynamics. (34) Research by Kawchuk, Fryer and colleagues determined that the sound of cavitation registered *before* the bubble collapsed. (2, 3, 34)

In other research Ohl and colleagues utilised hydrophones and ultrafast high speed photography at 20 million frames per second to note oscillations, acoustic noise and light emissions which may help overcome this limitation. This was a laboratory experiment conducted with the bubble formed in a cuvette. (38)

In attaining audible cavitation, Cramer cites Eisenberg as noting that the faster the manipulative impulse upon the facet adjustment, the more rapid the intra-articular pressure change of the synovial fluid, then the greater possibility of creating the audible element. (39)

Terms related generally to cavitation

Articular cavitation

The cavitation bubble is a phenomenon noted in a range of fields including physiology, embryology, and vascular plants but also in mechanical areas such as pumps, ship propellers and water falls. (40, 41, 42)

Acoustic cavitation, sonic cavitation, audible cavitation

The terms *acoustic cavitation* and *sonic cavitation* also relate to the dynamics of bubbles generated by an ultrasound field. It is suggested that *audible cavitation* differentiates the collapse of the bubble even though it has not been demonstrated that the collapse creates the crack sound of joint manipulation. (43, 44)

Bubble nucleation

Nucleation is the initial stage in bubble formation and is differentiated here from crystal nucleation in some arthritides. Meloni and colleagues present a detailed discussion on the formation of bubbles in fluids. This included the range of bubbles from nano-bubbles and micro bubbles which provide the nuclei for the more readily identifiable – radiolucent intra-articular cavitation. (45, 46, 47)

Non-Newtonian properties

Normally, synovial fluid is a non-Newtonian fluid in that viscosity may be influenced by changes of temperature or pressure. Variations in manual procedures are bound to change the viscosity of synovial fluid and may then vary the cavitation release of the articulation. (48, 49, 50, 51)

Viscoelastic coefficient

The viscoelasticity of synovial fluid is high as it serves as both a lubricant and a shock absorber. (52, 53, 54)

Strain field

Siegmund et al noted a *strain field* increased with capsular strain. While the subjects were cadaveric whiplash specimens, an association with cavitation was not conducted. However considering the mechanics of manipulation induced cavitation, strain field effect is a likely factor at least to some degree. (55)

Pressure coefficients.

Neu et al have detailed the molecular lubricating properties of cartilage with pressure coefficients (PCs). We could find no research for PCs in association with manual cavitation although it may be a peripheral factor. (56)

Light and black body radiation

Brennan notes the energy of '*collapsing cavitation…exhibiting properties of sound as well as light with black body radiation temperatures equal to that of the sun.*' While not recorded to our knowledge, if this feature involves articular cavitations, it may be a far weaker biological field to that noted in the research by Brennan. (40)

Friction Coefficient

While friction may not be a contributing factor in lineal distraction involving some cavitation procedures (e.g. MCP distraction) a number of z-joint manipulative releases involve release along the plane of an articulation. As noted with tribonucleation (below) it can be a feature of audible knuckle cracking. (57)

Continuum mechanics

Models of continuum mechanics have been developed for various biological tissues including cartilage, blood vessels. Humphrey acknowledges a role for continuum mechanics in health, disease and injuries. It involves the microstructure cellular response of cells of tissues and organs to physical forces. (58)

Sound volume of audible cavitation

In 2018 Suja and Barakat mathematically calculated that a collapsing bubble created a significant sound volume. (34) In recognising Kawchuk et al's finding of the persistence of the bubble *post-crack*, they suggest however that it may only be a partial collapse of the bubble that is responsible for the sound, and that bubble inception would not create the degree of sound volume noted. (2)

We hypothesise that this mathematical possibility of a *partial* collapse of the cavitation bubble may explain the double crack noted by Brodeur. (17)

The cavitation volume was monitored at a peak of 83 dB at 129Hz. (34) It was claimed that this was the equivalent to a diesel truck moving at 64.37 kph. (40 mph), heard from a distance of 15.25 metres (50 ft). This does not seem to equate with the acoustic cavitation of articular manipulation so familiar in the clinical setting. (59, 60)

Brodeur noted that in knuckle cracking, there are 'two sound peaks'. These were attributed firstly to the gas dissolving out of solution, and the second by the snap of the capsule reaching its length limit. He also states that the amount of energy involved is approximately 0.1 milli-joule per cubic millimetre. Brodeur also noted that the bubble is still evident after the double sound. (17)

Velocity of bubble collapse and shock waves

As a biological phenomenon, the speed of a bubble collapse is noted by Ohl et al in that '*For hard bio-materials (cornea, cartilage and bone), the bubble collapses towards the interface with high speed jets (between 100 and about 250 m s-1).*' (9, 42, 61) Kawchuk et al time the crack itself at just 310ms. (2)

In identifying the suction cup sound, Fryer proposed research of the association of audible synovial bubble collapse and the *negative amplitude shock wave pulse*. (4)

Tribonucleation

In 1967 the term tribonucleation defined the formation of a gas bubble which developed as a result of rubbing (62) which is quite a different mechanism to distraction of a joint. We would agree with Fryer that the initial intent of the term was that rubbing with a friction surface was quite different to its current use, and ideally an additional term would have been appropriate. However, as with cavitation, its widespread use would appear to have supplanted from the original intent. (4)

Tribonucleation has been defined as '*a mechanism that creates small gas bubbles by the action of making and breaking contact between solid surfaces immersed in a liquid containing dissolved gas. These small bubbles may then act as nuclei for the growth of bubbles when the pressure is reduced*'.

In 1970, Ikels described tribonucleation as a '*mechanism … for producing gas nuclei by making and breaking contact between solid bodies which are immersed in liquid.*' He also noted that the velocity of the distraction and the viscosity of the fluid influenced the formation of the bubble. (33) In addition, Campbell and others noted that the tribonucleation of bubbles in a liquid depended on the nature of the more solid adjacent surfaces involved. (64, 65)

If rubbing was the cause of cavitation in biological articulations, the degree of *rubbing* in normal finger flexion/extension that occurs in everyday life and could be expected to be a common cause of tribonucleation in virtually every individual. In addition, the synovial lubricated joint surfaces are noted for their low friction coefficient. (66)

Friction Coefficient

While friction may not be a contributing factor in lineal distraction involving some cavitation inducing procedures (e.g. MCP distraction) a number of z-joint manipulative releases involve releases parallel to the plane of an articulation.

Denucleated Fluid

Fryer et al found that denucleated fluids produced an audible cavitation. To produce an audible articular cavitation bubble dissolved gases must come out of solution under negative pressure to form micro-bubbles. These coalesce to become the visible cavitation itself. We assume that some dissolved gas remains in the fluid. (4)

This distraction of the joint reduces the synovial hydrostatic pressure within the joint and expands the synovia by 15%-20%. In turn, this allows the dissolved gases to escape from solution. An effect of this is to expand the joint and increase its mobility. (17)

Specificity

Under detailed spinal examination and often without the need for sensitive equipment, it is essential to localise the particular facet level of involvement for optimal outcomes. This requires differentiating 168 facet surfaces from C6/7 and L4/5 segments (67) and a further 26 between C0/C1 and C5/C6. With multiple facets at each level, it is critical to localise the lesioned facet for a specific adjustment as the articulations are 'close-packed'. (68, 69, 70, 71, 72, 73)

Clinical experience confirms the primary focus of the adjustment and impulse input is to be focused on the articulation identified with the segmental findings of dysfunction and associated signs and symptoms. It is noted that due to their proximity nearby articulations may cavitate as a secondary effect. The focal contact accuracy of adjusting instruments would tend to mitigate that with vectors being more concentrated. (74, 75)

Sonoluminescence

There is evidence of sonoluminescence when bubbles collapse. The light flash may occur in as little as 50 picoseconds. It is also heat producing inside a nucleated bubble in 'spots' measuring just 10 nanometers to 100 microns. (18, 19) The researchers of this study note that bubbles may nucleate, expand, and collapse, in response to the travelling sound wave of sonoluminescence. Whether energy of this magnitude is associated with audible articular cavitation appears yet to be determined. (19, 76 ,77)

Fryer and others also note a negative amplitude shock wave pulse with biological articular cavitation, although sonoluminescence has not been reported to be associated to date. (4, 38)

We recognise that to demonstrate this phenomenon *en vivo* may prove technically challenging.

Piezoelectric

The possibility of a piezoelectric effect being associated with sonic articular cavitation has been raised. (27, 28, 29, 30, 31) Cramer et al monitored this effect in their research with piezoelectric sensing accelerometers. (78)

In noting that some proteins can display semi-conductive piezoelectric and photoconductive properties in vitro, Hammer cites Oschman who states that every body movement generates an electric field. (79) While there is no direct evidence of such an association with articular cavitation through manipulation, this piezoelectric phenomenon may ultimately lead to an expansion of the knowledge regarding the cavitation mechanism. (80, 81)

Mechanotransduction and Piezo 1, Piezo 2 proteins

Tissue cells are responsive to mechanical forces and physical pressures. Piezos are membrane proteins which convert a variety of fast signalling mechanical stimuli into ion channel activation and subsequent inactivation. They have a potential role in '*mechanopathologies*'. They are typically involved with touch, pain, hearing, blood pressure through mechanotranduction. (82-85)

In a further biomechanical consideration, Weinbaum and colleagues note the possibility through mechanosensory transduction of osteocytes in the bone matrix sensing small e*n vivo* strains with relatively minor fluid shear stress, and further that high-frequency low-amplitude postural strains can increase bone mass. (86 ,87)

In 2003, Ingber discussed mechanical forces in health when he stated that '*The current focus of medicine on molecular genetics ignores the physical basis of disease even though many of the problems that lead to pain and morbidity, and bring patients to the doctor's office,* ***result from changes in tissue structure or mechanics****. The main goal of this article is therefore to help integrate mechanics into our understanding of the molecular basis of disease.*' (22) This statement may apply indirectly to cavitation and to subluxations it carries a significant message in relation to mechanobiology involving ***physical forces, maintenance of tissue form and function, and cellular response to mechanical stress.*** Mechanotransduction may also be considered in relation to subluxation. It has been defined as sensory transduction with the property of converting '*mechanical stimulus into an electrical signal, is a central mechanism to several physiological functions in mammals.*' Such concepts appear consistent with a physicomechanical model for management of particular conditions. (23, 88, 89)

Enigmas

In comparing radiolucencies elsewhere in the spine, it is noted that the gas produced in a degenerating intervertebral disc consists of 90%-95% nitrogen with the balance comprising CO_2 and O_2. (90, 91), yet the gas of the cavitation bubble in an articulation consists of 80% CO_2. (6)

Hjarbak et al noted this form of failing tissue consequence can be somewhat capricious. In a comparison of plain films and CTs, they found 1:5 plain films reveal gaseous lucencies, while CTs reveal 1:2 have this sign of degeneration – from 20% compared to 50%. We could not confirm the gas constituents of these intra-articular radiolucencies, but would presume them to be similar to those in the intervertebral disc. (92)

In relation to these gaseous radiolucencies associated with intervertebral disc degeneration, they have been labelled vacuum phenomenon, (93),while Coulier designated them a complex hydropneumatical continuum, while Wilkinson et al and others nominated them as pneumatocysts. (94, 95)

DISCUSSION

Much of the research on cavitation has focussed on the metacarpophalangeal joints, while apart from Cramer et al, similar studies of *distraction* on vertebral facets have been comparatively limited. (96)

Extensive original research by Cramer and colleagues expanded the evidence on cavitation and facet morphology of lumbar vertebral facets under manipulation. Their research demonstrated definitive gapping of lumbar facets under chiropractic adjustment with cavitating joints gapping more than non-cavitating joints. (39, 68, 78, 96, 97)

While much research has taken place on cavitation, it is a broad topic especially when it takes in the fields of biology, cardiac devices, diving (bends), ultrasound, activated drug delivery, surgery (cataract, lithotripsy), as well in non-biological mechanical causes such as churning ship propellers. (40)

While there are some similarities in vertebral facet cavitation compared to MCPs, it is suggested that there are also notable differences from which to draw comparative conclusions between the disparate articulations. (98, 99)

The immediate difference to note is the determination of whether the distraction induced cavitation of a *normally functioning* MCP is comparable to that of a *dysfunctionally subluxated* vertebral facet – or a vertebra addressed with a rotary adjustment vector parallel to the plane of the facet instead of lineal distraction. The hypomobility factor in a vertebral subluxation dysfunction may result in a significantly different audible cavitation to that in a freely moving MCP or interphalangeal articulation.

Other differences include:

- The morphology contrasts between the slightly concave surface of the proximal metacarpal with the milder contour of the surface of the articulating phalanx;
- The type of motion or functional physiology between the MCP and the z-joints are distinctly different. MCPs having a far greater range of movement and a distinctly different range of motion;
- The shape and depth of the cartilage of the MCP joint itself appears to be comparatively different to the cartilage on z-joints, where facet surfaces are relatively shallow, almost flat;
- The degree of anatomical joint space separation appears appreciably different;

- Facets have a weight-bearing function and limited motion contrasting to an MCP which primarily exhibit flexibility in a single plane;
- We note the comparison of cavitation induced in a normally functioning MCP to a manipulation conducted on a dysfunctional z-joint; (10,93)
- Z-joints have instantaneous axes of motion in a range of directions along their centrode, whereas MCPs and interphalangeal articulations are comparatively limited to the plane of flexion /extension;
- There is a different ligamentous and capsule structure which permits greater joint laxity and range of motion with the MCPs than z-joints.
- Manipulative cavitation release of facets of the various spinal regions take place in very different planes to each other; (39)
- The line of impulse thrust is often parallel to the plane of the vertebral articulation with minimal distractive separation, rather than perpendicular to it as in the case of MCP distraction;
- Cavitation generally occurs at the extreme of motion with MCPs, but not necessarily with the adjustment of vertebral facets where the joint can be released well before the facet reaches its end range of motion. (10)
- We note that the manual force required to produce audible cavitation in an MCP by distraction seems significantly greater than that required to release cavitation in a vertebral articulation;
- It is noted that cavitation of a phalangeal or metacarpophalangeal joint is not necessarily subluxated in order to produce cavitation, nor does it approximate the limit of its physiological range (other than the distraction limit). [This may raise the question as to whether a dysfunctional vertebral facet can be symptomatic without fixation or cavitation!]

Kawchuk's 2015 research confirmed that the audible cavitation occurs before the collapse of the bubble. (2) It would then seem feasible that the sound could be similar to that made by the physical separation of synovial joint surfaces under negative pressure suction. This may be regarded as a form of release similar to a Magdeberg effect with the sudden separation of metal plates or hemispheres under vacuum. (Otto von Guericke's 1657) (100, 101) This could also be likened to the sudden removal of a suction cup from a smooth lubricated glass (3) surface. In effect a sudden mechanical suction release under viscous adhesion. (34) This would be in keeping with Evans description of a toroidal collapse and noted by Ebrall. (21, 98)

Neurological

The neurology of cavitation is a significant consideration. Apart from the activation of sensory mechanoreceptors with the release of fixated vertebral articulations, the activation of somato-autonomic reflexes and neutralising of noxious sensory input may influence visceral and somatic structures. Such changes are also reflected clinically by the diminution of associated signs and symptoms, especially pain. (71, 102, 103, 104, 105, 106, 107, 108)

In a further indication, Gyer and colleagues found '*A growing number of recent studies have indicated peripheral, spinal and supraspinal mechanisms of manipulation and suggested that the improved clinical outcomes are largely of neurophysiological origin.' and further that 'The body of literature reviewed herein suggested some clear neurophysiological changes following spinal manipulation, which include neural plastic changes, alteration in motor neuron excitability, increase in cortical drive.*' (109)

In further association of this phenomenon, Clark et al indicated '*that the stretch reflex is attenuated when SM causes an audible response. This finding provides insight into the mechanisms of SM, and suggests that SM that produces an audible response may mechanistically act to decrease the sensitivity of the muscle spindles and/or the various segmental sites of the Ia reflex pathway.*' (110)

The second study conducted by Fryer and Pearce [58] on asymptomatic participants. The authors demonstrated a significant reduction in corticospinal and spinal reflex excitability following HVLA manipulation that produced an audible cavitation. (111)

The distinct difference of an audible manipulative articular release, an instrument initiated articular release without audible cavitation. The Activator instrument has a speed 20-30 times faster than manual techniques and approximately 5 times faster than a muscle spindle reflex. (112, 113, 114) The authors note further that a fixation may be aggressed without audible cavitation through the use of such an impulse adjusting instruments.

Brodeur opines that without the cavitation process, it would be difficult to generate the necessary forces without causing muscular damage given that the articular release occurs faster than a stretch reflex of the periarticular intrinsic muscles. (6)

Efficacy of cavitation as evidence of articular release

In a comparative study, Mierau and colleagues noted that manipulation differed from mobilisation of metacarpophalangeal joints in efficacy for improving joint range of motion. Manipulation showed *'significant increase in passive flexion over mobilisation*' .The authors state that the two therapies should not be considered equivalent. (93)

Clinical evidence indicates that cavitation is a pathophysiological phenomenon which can be clinically significant, particularly when it is associated with signs and symptoms of a segmental subluxation or fixation. This is further confirmed with alleviation of those associated signs and symptoms following correction of the subluxation and release of the fixation element of the articular dysfunction. (115, 116, 117, 118, 119, 120)

Conclusion

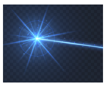
Since embarking on this topic it has become apparent that the audible cavitation is a far more complex phenomenon than first thought. It has developed from a relatively simple biomechanics 'pop' into a complex involving nano-bubbles, quantum physics, and mathematics.

We note the distinct morphological and physiological articular differences between the MCP and the vertebral facets, and suggest there may also be differences in the functional release as well as the audible cavitation of each type of articulation.

Cramer et al state that '*the greater the tissue resistance to gapping the more likely a joint may cavitate*.' (39) while others describe *viscous adhesiveness* and facet joint adhesiveness in procuring cavitation of joints. (3, 4, 48) We concur with this factor as one which may define the mechanical breaking of the joint suction.

This is in keeping with Fryer's negative amplitude shock wave pulse model of MCP joints. Cramer et al also noted that an audible cavitation was an indicator of successful joint surface separation. (39)

While an adjustment is not always associated with an audible cavitation, the sound does signify a response – and an expected contribution towards amelioration of signs and symptoms, both to the patient, as well as to the practitioner as a positive indication for the intervention. (21, 93)



Peter Rome
DC (ret), FICC
cadaps@bigpond.net.au

John D Waterhouse
DC, FACC
Private practice, Melbourne

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