THE JOURNAL OF ALTERNATIVE AND COMPLEMENTARY MEDICINE
Volume 17, Number 12, 2011, pp. 1119–1124

DOI: 10.1089/acm.2010.0740

The Relationship Between Dental Occlusion/Temporomandibular Joint Status and General Body Health: Part 2. Fascial Connection of TMJ with Other Parts of the Body

Hyung-Joo Moon, DDS, MSD, PhD,[1] and Yong-Keun Lee, DDS, MSD, PhD[1,2]

Abstract

In part 1 of this study, it was discussed that dental occlusion/temporomandibular joint (TMJ) status is functionally connected to general body health. The purpose of this part of the study was to attempt to formulate a conceptual account, the "fascial connection theory for TMJ and other parts of the body," to explain the functional connection between TMJ and other parts of the body. The first hypothesis that was studied is that TMJ and other parts of body are connected through the fascia as asserted by the myofascial-release schools, and the second one is that they are connected through the meridian system constituted of fascia (connective tissue). The fascial connection theory proposed here can explain the functional connection between dental occlusion/TMJ and other parts of the body based on either myofascial release or the *qi* and meridian system, or a combination of the two. Therefore, dental occlusion should be built up and maintained in a normal natural condition, and causes of deterioration of TMJ status should be treated in an effort to restore the natural condition. Other possible mechanisms that can account for these connections require elucidation, and additional experimental investigation should be undertaken.

Introduction

As discussed in part 1 of this study, dental occlusion/temporomandibular joint (TMJ) status and general body health have organic and functional relationships. However, there has been no interpretation accounting for the anatomical or functional mechanism for these relationships. Therefore, a conceptual model that can explain these relationships is needed, and the primary candidate is the fascial connections through the whole body.

TMJ disorders can originate from or have an impact on these fascial connections, and therefore treatments are needed that take the whole body into account.[1,2] A possible relationship between dental occlusion and posture control has been postulated,[3–5] and occlusion and head position have been shown to affect body balance, resulting in a change of falling risks.[6,7] There is a close relationship between occlusal support and head posture,[8] and tooth loss has been proposed to affect postural control.[9] The effect of experimental muscle pain on the muscle spindle primary afferent neurons in the trigeminal mesencephalic nucleus was examined, and it was concluded that the activation of masseter muscle nociceptor alters spindle afferent responses to stretch.[10] In the mesencephalic nucleus of the trigeminal nerve, two types of unit were found, namely, muscle spindle first-order afferents of ipsilateral jaw-closing muscles and mechanoreceptor afferents of ipsilateral maxillary and mandibular teeth.[11]

Although discussed in part 1, the reasons why the TMJ is important in general body health should be reiterated. In light of the reports cited in part 1, effects of the TMJ on the brain and spinal cord need to be emphasized, and recent advancement in craniosacral therapy,[12] which can further account for the importance of the TMJ, also needs to be introduced here. Since the TMJ is so close to the brain, ears, eyes, and vestibular balancing system, the proper mandible position in the mandibular fossa is important.[13] The vestibulo-ocular reflex is a reflex eye movement that stabilizes images on the retina during head movement by producing an eye movement in the direction opposite to head movement. When the head translates, for example, during

[1]Moon Dental Hospital, Seoul, Korea.
[2]Institute for Clinical Performance of Biomaterials, Seoul, Korea.

walking, the visual fixation point is maintained by rotating gaze direction in the opposite direction, by an amount that depends on distance.[14] As to the influence of the vestibulo-ocular reflex on the TMJ, when muscles in the back of the neck shorten by whiplash injury or others, to compensate, the head moves slightly forward to keep the eyes parallel to the ground. This causes increased tension in front of the neck muscles, which attach to the lower jaw. These sequential processes cause stress in the TMJ.[1] The symptoms due to TMJ disorders are blurring of vision, ear pain and noise,[15] sensitivity to sound, deafness, aerotitis media, staggering gait, vertigo, dizziness, nausea, vomiting, abdominal pain, blackouts, and even loss of consciousness.[13,16]

With regard to the craniosacral therapeutic aspect, the authors would like to reemphasize that the circulation of the cerebrospinal fluid might be influenced by the TMJ, especially when abnormal strain around the TMJ caused by inappropriate vertical height and/or lateral balance exists.[17] There are well-known debates on the craniosacral rhythm, with the major point being that the cranial bones do not move, because with maturity the sutures become ossified.[18] However, a new hypothesis was recently proposed,[12] in which the influence of the thickness of the cranial bone, and hence the relative flexibility, was considered. In this mode, the apparent motion of the sphenobasilar synchondrosis takes place by a change in shape of the anterior body of the sphenoid, and this motion is accommodated by the superior orbital fissure. Therefore, this new model does not require sutures to be patent or membranous. In addition to this new hypothesis, the closure degree of sphenobasilar synchondrosis and its relationship with chronological age was examined recently.[19] The results showed mean ages of open, semiclosed, and closed sutures were 12.3, 16.1, and 21.2 years in males, and 9.0, 12.4, and 19.4 in females, based on which, the movement of this suture is possible around 20 years of age. Rapid maxillary expansion leads to a small immediate widening of the sphenobasilar synchondrosis in young people.[20] Based on these recent findings, it is thought that dental occlusion/TMJ status influence the cerebrospinal fluid circulation, because high-strength masticatory muscles such as the masseter muscle can influence the strain patterns, and as a result the shape of cranial bones. In this sense, abnormal positioning of the teeth and the TMJ influence the muscle tone of the head area, which in turn influences the cranial bone movement and cerebrospinal fluid circulation. In addition to these effects, muscle strain or other stress around the TMJ can induce changes in the brain and spinal cord.[21] The balance and movement of occiput, atlas, and axis complex and their impact on the dural meninges and cerebral spinal fluid are factors in head posture and TMJ righting as well as autonomic function.[17]

Another possibility is posed by fibromyalgia. Although the exact causes of fibromyalgia are unknown, cerebrospinal fluid abnormalities were put forward as one of the causes.[22–25] It was also reported that fibromyalgia was diagnosed 13 times more frequently following neck injury than following lower extremity injury.[26] This might be explained partially by the anatomical closeness of the head and neck to the central nervous system.[27]

The purpose of this part of the study was to attempt to formulate a conceptual account, the "fascial connection theory for TMJ and other parts of the body," to explain the functional connection between TMJ and other parts of the body. This theory may have a basis in either the myofascial release aspect or the *qi* and meridians, or a combination of the two.

Hypothesis Based on Myofascial Release Aspect

The first hypothesis proposes that TMJ and other parts of the body are connected through the fascia, as claimed by the myofascial-release schools.

Myofascial release and trigger point

Before starting this section, certain characteristics of the fascia are briefly reviewed. The fascia is the connective tissue found everywhere in the body that holds all of the organs in place, and surrounds and invades every tissue and organ, including nerves, blood vessels, muscle and bone, even down to the cellular level.[1,28,29] The fascia (1) supports and stabilizes, thus enhancing the postural balance of the body; (2) aids in the circulation of the blood and lymphatic fluids; and (3) is a major site of inflammation propagation. Among the fascial tissues, the myofascia permeates through muscle, first wrapping individual muscle fibers, and then bundles of the muscle fibers, and finally the entire muscle structure.[1] Based on optical imaging of the fascia, it was found that fibrillar arrangement of collagen type I structures is the main matrix component of the fascia Muscle fascia is a three-dimensional sheet structure enwrapping muscle bundles. It maintains structural integrity, and is involved in intercellular communication.[30]

The fascia is considered an important element in musculoskeletal pain, and has been described as an element of connection between different anatomical structures.[31] Others also have focused on the role of the fascia as a three-dimensional network extending throughout the whole body.[32,33] This connective tissue network is stretched by the contraction of underlying muscles and can transmit tension at a distance.[34,35] The fasciae are normally thought of as passive structures that transmit mechanical tension generated by muscular activities or external forces throughout the body. Some research suggested that the fasciae might be able to contract independently and thus actively influence muscle dynamics.[36] Therefore, myofascial force transmission should be taken into account when considering muscular function and its coordination, and in clinical decisions.

Additionally, the central nervous system is surrounded by the fascia; therefore, dysfunction in the fascia can have widespread neurological effects. The majority of the fascial tissues are arranged vertically, from head to toe, and there are four interconnected transverse fascial planes that criss-cross the body in a weblike manner. Therefore, if injury occurs in one part of the body, pain and dysfunction may result throughout the body because of this interconnecting system.[1,37,38] When the fascia malfunctions due to injury, illness, surgery, poor posture, or inflammation, it becomes tight and clamps, resulting in abnormal pressure on the nerves, muscles, bones, and organs. This excessive pressure can produce pain, headache, TMJ disorder, and restriction of motion.[1,37,38]

TMJ and myofascial release

When muscles become tense or go into spasm, hard nodules called myofascial trigger points are formed. Trigger points are a common cause of mucoskeletal pain and

dysfunction.[1,39,40]Referred pain is felt in areas remote from the trigger points such as the TMJ, which is defined as pain that is referred to a part of the body other than the site of origin, and is common in the orofacial region.[41]

Clinicians now appreciate the full chain of tissue damage of the interconnecting muscles, tendons, ligaments, and fascia. If one is to treat the occlusion of these victims intelligently, one must understand the effects of this trauma on the whole body, and not just focus singularly on the restoration or the malocclusion or the TMJ problem.[42] It has been argued that as many as 80%–90% of all TMJ disorders are related to the muscles of the body and that almost all TMJ disorder patients have referred pain originated from some muscles from head to toe.[1,43] By removing the trigger points, referred pain will be eliminated, and importantly, these referred pain patterns are predictable. In the reverse situation (i.e., when the TMJ is afflicted with abnormalities such as a reduced vertical dimension or lateral deviation), the related muscles begin to hold a tense and abnormal position; muscle spasms occur, and before long the tension travels by chain reaction throughout the body.[1] As to the trigger points in the TMJ area, a trigger point that resembled a painful tooth with endodontic involvement was discussed.[41] An application of dry needling into the trigger points in the masseter muscle induced significant increases in the pressure pain threshold levels when compared to sham dry needling in patients with myofascial TMJ disorders.[43]

Based on these reported findings, it can be proposed that fascial connections at both the microscopic and macroscopic level in the organs throughout the body influence each other and thereby coordinate the entire body. As the myofascial-release schools have insisted, muscles and the TMJ have a close connection with one another through the fascia. Therefore, dental occlusion and TMJ status exert a powerful impact on general body health.

Hypothesis Based on *Qi* and Meridian Aspect

The second hypothesis proposes that the TMJ and other parts of the body are connected through the meridian system constituting the fascia (connective tissue). In this section, after a brief review of the meridian system, the relationship between the meridian system and fascia is reviewed. The "needle-grasp" phenomenon is reviewed to determine whether there is further support for the anatomical relationship between the meridians and fasciae, and then two models that are able to explain the remote effects of acupuncture, which can thus support the fascial connection theory, are presented.

Definitions

According to Traditional Chinese Medicine, *qi* is an active principle of vitality forming an essential part of every living thing. The meridians are channels along which the *qi* is considered to flow. Acupuncture is the procedure of inserting and manipulating needles into various points on the body to relieve pain or for therapeutic purposes.[44] According to the World Health Organization, the definition of acupuncture is the stimulation of acupuncture points using needles, moxibustion, electricity, laser, or acupressure for therapeutic purposes.[44] Modern acupuncture charts indicate 12 principal meridians, and acupuncture points are located along the meridians.[45]

Anatomical relationship between acupuncture meridian and fascia

Acupuncture meridians traditionally are believed to form a network throughout the body, connecting peripheral tissues to each other.[46] Studies to understand the acupuncture point/meridian systems from a Western perspective have mainly sought to identify the distinct histological features that differentiate acupuncture points from surrounding tissue,[47] and one of the histological and anatomical associations for the meridians is the intermuscular or intramuscular loose connective tissue (fascia). The anatomical characteristics of the acupuncture point and meridian system were reviewed recently,[48] which focused on two relevant anatomical associations such as nervous system and connective tissue. The nervous system correlates reported include peripheral nerves, neurovascular bundles, motor points, mechanoreceptors, free nerve endings, and neuromuscular attachments. However, no anatomical neural structure was clearly linked with the acupuncture points.

In terms of connective tissue associations, besides the fact that ancient acupuncture texts contain several references to "fat, greasy membranes, fasciae and systems of connecting membranes" through which the *qi* is believed to flow,[49] several authors have suggested that a correspondence might exist between the acupuncture meridians and the connective tissue, and the acupuncture meridians tend to be located along the fascial planes between muscles or between a muscle and bone or tendon.[47,49–51] Additionally, the collagen within the loose connective tissue might account for the needle-grasp phenomenon at the acupuncture points.[47,52,53]

In terms of experimental evidences, it was hypothesized that the network of the meridians could be viewed as a representation of a network of interstitial connective tissues, and this hypothesis was supported by ultrasound images showing connective tissue cleavage planes at the acupuncture points in humans. It was also reported that the anatomical relationship of the meridians to connective tissue planes is related to the acupuncture mechanism of action.[47] Rather than viewing acupuncture points as discrete entities, it has been proposed that these points might correspond to sites of convergence in a network of connective tissue permeating the entire body, analogous to highway intersections in a network of primary and secondary roads.[47] According to this road analogy, the interaction of an acupuncture needle with connective tissue would occur even at the smallest connective tissue secondary road. However, needling a major highway intersection would have more powerful effects, perhaps due to collagen fiber alignment leading to more effective force transduction and signal propagation at those points.

Support by the needle-grasp phenomenon

The Chinese character signifying the acupuncture point means a hole,[45] conveying the impression that acupuncture points are locations where the needle can gain access to deeper tissue. In acupuncture treatments, acupuncture needles are manipulated after their insertion, and needle manipulation typically consists of rapid rotation and/or pistoning of the needle.[45,47] During needle manipulation, acupuncturists aim to elicit a characteristic reaction known as "*de qi*" or "obtaining *qi*," widely viewed as essential to the

therapeutic effect. During *de qi*, the patient feels an aching or needling sensation in the acupuncture area, and the acupuncturist feels pulling and increased resistance to further movement of the inserted needle, a tug on the needle that is referred as the needle grasp.[47,53] The needle grasp is therefore a measurable biomechanical phenomenon.[52]

A needle inserted at the site of a connective tissue cleavage plane penetrates first through the dermis and subcutaneous tissue, then through the deeper, interstitial connective tissue. Because the needle grasp involves an interaction of the needle with connective tissue,[53] the enhanced needle-grasp response at acupuncture points might be due to the needle coming into contact with connective tissue at those points. It was experimentally confirmed that the presence of needle grasp was consistent with the amount of connective tissue. According to the experimental evidence, the connective tissue response to the acupuncture needling was quantitatively different at acupuncture points compared with control points.[52] Collagen within the loose connective tissue might account for the needle grasp at the acupuncture points.[48,52,53]

Two models of the remote effects

Needling the acupuncture points has effects remote from the site of needle insertion, and these effects are mediated by the meridian system.[28] Physiologic models for these remote effects have been basically attributed to the nervous system[54,55]; however, the connective tissue network has been considered currently.[53] In the following, the action mechanisms for the remote effect of acupuncture through the meridian system and the corresponding fascial connective tissue networking are briefly reviewed according to the two previously introduced models such of durotaxis and chemotaxis.

In the durotaxis (mechanotaxis) model, biophysical force such as mechanical and electrical forces acting on the cell surface lead to intracellular and intercellular architectural remodeling, which result with biochemical reactions.[56] It has been suggested that (1) the needle grasp is due to mechanical coupling between the needle and connective tissue, with tissue winding around the needle during needle rotation; and (2) needle manipulation transmits a mechanical signal to connective tissue cells via mechanotransduction. Such a mechanism might explain both the local and remote as well as long-term effects of the acupuncture.[53]

The chemotactic effect also has been proposed to explain the remote effect. Connective tissue interstitial fluid (CTIF) system forms a body fascia frame with connected layers,[57] which embeds the neurovascular tracts and connects the tunicae around the visceral organs. The frame also extends to form the periosteum.[58] It was suggested that the anatomical structure of meridian channels was related to the connective tissues and the CTIF system.[47] Based on an interdisciplinary analysis of the CTIF system, a unique hypothesis for the meridian structure plus acupuncture physiology was proposed.[59] This hypothesis is that the meridian system is a special channel network comprised of skin, having abundant nerves and nociceptive receptors, together with deeper connective tissues inside the body with the CTIF. Furthermore, these meridian channels provide efficient migratory tracks, mainly by durotaxis and chemotaxis, for mast cells, fibroblasts, and other cells to migrate and carry out physiologic functions. To confirm this experimentally, nuclear tracers were used to track the trajectory of the acupuncture meridians, and it was confirmed that the tracer migrated along the course of the meridians at a rate of 3–5 cm per minute when injected into acupuncture points.[60] In areas where the tracer was injected at nearby control points, the migration was not observed,[61] and this phenomenon was not directly attributable to veins or lymphatics, although the interpretation remains controversial.[60]

Either of these two models or a combination of the two can explain in part the remote effects of the acupuncture, and the fascial connection theory might be further supported by these models.

Correlation Between Trigger Points and Acupuncture Points

Although separated in their origins by 2000 years, the acupuncture and myofascial pain traditions share certain fundamental similarities in the treatment of pain disorders. Therefore, myofascial pain data and research might help in elucidating the mechanisms of acupuncture.[62] Recent reports suggested substantial anatomical, clinical, and physiologic overlap of the myofascial trigger points and acupuncture points.[62] The myofascial referred pain data provide independent physiologic evidence for the acupuncture meridians, and inversely, the acupuncture tradition provides pain practitioners with its copious accumulated clinical experience in treating pain and visceral disorders, and offers novel pain treatment approaches and a better understanding of pain neurophysiology.

The analogy between the trigger points and acupuncture points have been discussed since 1977,[63] in which it was reported that there were 100% anatomical and 71% clinical pain correspondences for the myofascial trigger points and acupuncture points in the treatment of pain disorders. A number of similarities between them were also suggested: the two structures have similar locations; needles are used at either point to treat pain; the pain associated with the local twitch response at trigger points is similar to the *de qi* sensation; and the referred pain generated by needling trigger points is similar to the propagated sensation along the meridians.

In terms of experimental evidences, the remote effect of the acupuncture on the pain intensity recorded at a myofascial trigger point of a muscle was investigated.[64] Changes in the pain intensity in the myofascial trigger point region were found during and after the acupuncture treatment at remote ipsilateral acupuncture points. Cerebral hemodynamic responses during the acupuncture stimulation at the trigger points and nontrigger points were recorded by functional near-infrared spectroscopy,[65] and the findings suggested that *de qi* sensations favorably predicted acupuncture effects on cerebral hemodynamics regardless of the type of site stimulated.

However, it was pointed out that the acupuncture points located at the trigger points are not frequently used by acupuncturists, and do not share the same clinical indications as the trigger point therapy.[66] It was further argued that the claim of 71% correspondence between the acupuncture points and the trigger points[63] was not possible conceptually. Furthermore, even putting this conceptual

problem aside, no more than 40% of the acupuncture points correlated with the treatment for pain, and more likely, only approximately 18%–19% of the points are actually correlated.[67] The correlation between the trigger points and the acupuncture points clearly will need further investigation in the future.

Conclusions

The fascial connection theory proposed here can explain the functional connection between dental occlusion/TMJ and other parts of the body based on either the myofascial release or the *qi* and meridian aspect, or a combination of the two. Dental occlusion and TMJ status exert a powerful influence on general body health, in part because these structures are very close to the central nervous system. Therefore, dental occlusion and TMJ status should be maintained, and when necessary, restored as closely as possible to the natural condition. Further possible mechanisms that can elucidate these connections should be searched for in the complementary and alternative medicine field, and experiment-based research should be followed.

Disclosure Statement

No competing financial interests exist.

References

1. Uppgaard RO. Taking Control of TMJ. Oakland, CA: New Harbinger Publications, 1999:7,8,11,13,16,18,24,32,45–56, 128,129
2. Gelb H, Calderone JP, Gross SM, Kantor ME. The role of the dentist and the otolaryngologist in evaluating temporomandibular joint syndromes. J Prosthet Dent 1967;18: 497–503.
3. Huggare J. Association between morphology of the first cervical vertebra, head posture, and craniofacial structures. Eur J Orthod 1991;13:435–440.
4. Bracco P. Observations on the correlation between posture and jaw position: A pilot study. J Craniomandib Pract 1998; 16:252–258.
5. Gelb H, Bernstein I. Clinical evaluation of two hundred patients with temporomandibular joint syndrome. J Prosthet Dent 1983;49:234–243.
6. Hellsing E, Hagberg C. Changes in maximum bite force related to extension of the head. Eur J Orthod 1990;12:148–153.
7. Makofsky HW, Sexton TR, Diamond DZ, Sexton MT. The effect of head posture on muscle contact position using T-scan system of occlusal analysis. Cranio 1991;9:316–321.
8. Kibana Y, Ishijima Y, Hirai T. Occlusal support and head posture. J Oral Rehabil 2002;29:58–63.
9. Yoshida M, Kikutani T, Okada G, et al. The effect of tooth loss on body balance control among community-dwelling elderly persons. Int J Prosthodont 2009;22:137–139.
10. Masri R, Ro JY, Capra N. The effect of experimental muscle pain on the amplitude and velocity sensitivity of jaw closing muscle spindle afferents. Brain Res 2005;1050:138–147.
11. Cody FW, Lee RW, Taylor A. A functional analysis of the components of the mesencephalic nucleus of the fifth nerve in the cat. J Physiol 1972;226:249–261.
12. Cook A. The mechanics of cranial motion: The sphenobasilar synchondrosis (SBS) revisited. J Bodywork Move Ther 2005;9:177–188.
13. Taylor PL. TMJ Cured: Fixing the Bite Is the Answer. Palm Desert: Truth in Dentistry Publishing, 2010:9,13,14,41–55,84–89.
14. Angelaki DE. Eyes on target: What neurons must do for the vestibuloocular reflex during linear motion. J Neurophysiol 2004;92:20–35.
15. Gelb H, Gelb ML, Wagner ML. The relationship of tinnitus to craniocervical mandibular disorders. Cranio 1997;15:136–143.
16. Kelly HT, Goodfriend DJ. Vertigo attributable to dental and temporomandibular joint causes. J Prosthet Dent 1964;14: 159–173.
17. Libin BM. The cranial mechanism: Its relationship to cranial-mandibular function. J Prosthet Dent 1987;58:632–638.
18. Madeline LA, Elster AD. Suture closure in the human chondrocranium: CT assessment. Radiology 1995;196:747–756.
19. Akhlaghi M, Taghaddosinejad F, Sheikhazadi A, et al. Age-at-death estimation based on the macroscopic examination of spheno-occipital sutures. J Forensic Leg Med 2010;17:304–308.
20. Leonardi R, Cutrera A, Barbato E. Rapid maxillary expansion affects the spheno-occipital synchondrosis in youngsters: A study with low-dose computed tomography. Angle Orthod 2010;80:106–110.
21. Guzay CM. Efficiency in occlusal function. Basal Facts 1985; 7:228–246.
22. Vaerøy H, Nyberg F, Terenius L. No evidence for endorphin deficiency in fibromyalgia following investigation of cerebrospinal fluid (CSF) dynorphin A and Met-enkephalin-Arg6-Phe7. Pain 1991;46:139–143.
23. Russell IJ, Orr MD, Littman B, et al. Elevated cerebrospinal fluid levels of substance P in patients with the fibromyalgia syndrome. Arthritis Rheum 1994;37:1593–1601.
24. Larson AA, Giovengo SL, Russell IJ, Michalek JE. Changes in the concentrations of amino acids in the cerebrospinal fluid that correlate with pain in patients with fibromyalgia: Implications for nitric oxide pathways. Pain 2000;87:201–211.
25. Gelb H, Calderone JP, Gross SM, Kantor ME. The role of the dentist and the otolaryngologist in evaluating temporomandibular joint syndromes. J Prosthet Dent 1967;18:497–503.
26. Buskila D, Neumann L, Vaisberg G, et al. Increased rates of fibromyalgia following cervical spine injury: A controlled study of 161 cases of traumatic injury. Arthritis Rheum 1997;40:446–452.
27. Truta MP, Santucci ET. Head and neck fibromyalgia and temporomandibular arthralgia. Otolaryngol Clin North Am 1989;22:1159–1171.
28. Butler J. Conquering carpal tunnel syndrome and other repetitive strain injuries. Oakland, CA: New Harbinger Publications, 1996:156.
29. Comeaux Z. Harmonic Healing: A Guide to Facilitated Oscillatory Release and Other Rhythmic Myofascial Technique. Berkeley: North Atlantic Books, 2008:87–89.
30. Pfeffer CP, Olsen BR, Ganikhanov F, Légaré F. Multimodal nonlinear optical imaging of collagen arrays. J Struct Biol 2008;164:140–145.
31. Rolf I. Rolfing: The Integration of Human Structures. New York: Harper Collins, 1989.
32. Myers TW. Anatomy Trains. Oxford: Churchill Livingstone, 2001:171–194.
33. Langevin HM. Connective tissue: A body-wide signaling network? Med Hypotheses 2006;66:1074–1077.

34. Maas H, Meijer JM, Huijing PA. Intermuscular interactions between synergists in rat originates from both intermuscular and extramuscular myofascial force transmission. Cells Tissues Organs 2005;181:38–50.
35. Meijer HJ, Baan GC, Huijing PA. Myofascial force transmission is increasingly important at lower forces: firing frequency related length-force characteristics of rat extensor digitorum longus. Acta Physiol 2006;186:185–195.
36. Schleip R, Klingler W, Lehmann-Horn F. Active fascial contractility: Fascia may be able to contract in a smooth muscle-like manner and thereby influence musculoskeletal dynamics. Med Hypotheses 2005;65:273–277.
37. Barnes JF. Myofascial Release: The Search for Excellence—A Comprehensive Evaluation and Treatment Approach. Paoli, PA: MFR Publications, 1990.
38. Delaune V. Trigger point therapy for headaches & migraine. Oakland, CA: New Harbinger Publications, 2008.
39. Simmons DG. Clinical and etiological update of myofascial pain from trigger points. J Musculoskel Pain 1996;4:93–121.
40. Simmons DG. Myofascial pain from trigger points: The critical experiment. J Musculoskel Pain 1997;5:113–118.
41. Reeh ES, elDeeb ME. Referred pain of muscular origin resembling endodontic involvement: Case report. Oral Surg Oral Med Oral Pathol 1991;71:223–227.
42. O'Shaughnessy T. Craniomandibular/temporomandibular/cervical implications of a forced hyper-extension/hyperflexion episode (i.e., whiplash). Funct Orthod 1994;11:5–12.
43. Fernández-Carnero J, La Touche R, Ortega-Santiago R, et al. Short-term effects of dry needling of active myofascial trigger points in the masseter muscle in patients with temporomandibular disorders. J Orofac Pain 2010;24:106–112.
44. World Health Organization. Acupuncture: Review and Analysis of Reports on Controlled Clinical Trials. Geneva: WHO, 2002.
45. O'Connor J, Bensky D. Acupuncture, a Comprehensive Text (Shanghai College of Traditional Medicine). Seattle: Eastland Press, 1981.
46. Kaptchuk TJ. The Web That Has No Weaver: Understanding Chinese Medicine. Chicago: Contemporary Publishing Group, 2000.
47. Langevin HM, Yandow JA. Relationship of acupuncture points and meridians to connective tissue planes. Anat Rec 2002;269:257–265.
48. Napadow V, Ahn A, Longhurst J, et al. The status and future of acupuncture mechanism research. J Altern Complement Med 2008;14:861–869.
49. Matsumoto K, Birch S. Hara Diagnosis: Reflections of the Sea. Taos, NM: Paradigm Publications, 1988.
50. Cheng X. Chinese Acupuncture and Moxibustion. Beijing: Foreign Language Press, 1987.
51. Ho MW, Knight DP. The acupuncture system and the liquid crystalline collagen fibers of the connective tissues. Am J Chin Med 1998;26:251–263.
52. Langevin HM, Churchill DL, Fox JR, et al. Biomechanical response to acupuncture needling in humans. J Appl Physiol 2001;91:2471–2478.
53. Langevin HM, Churchill DL, Wu J, et al. Evidence of connective tissue involvement in acupuncture. FASEB J 2002;16:872–874.
54. Ulett GA, Han S, Han JS. Electroacupuncture: Mechanisms and clinical applications. Biol Psych 1998;44:129–138.
55. Pomeranz B. Acupuncture analgesia: Basic research. In: Stux G, Hammerschlag R, eds. Clinical Acupuncture: Scientific Basis. Berlin: Springer-Verlag, 2001.
56. Ingber DE. Tensegrity: The architectural basis of cellular mechanotransduction. Annu Rev Physiol 1997;59:575–599.
57. Page KE. The Role of the Fascia in the Maintenance of Structural Integrity. Newark: Academy of Applied Osteopathy Yearbook, 1952:70.
58. Mayes PA, Murray RK, Granner DK, Rodwell VW. Harper's Biochemistry, 25th ed. New York: McGraw-Hill Publishing, 2000:707.
59. Fung PC. Probing the mystery of Chinese medicine meridian channels with special emphasis on the connective tissue interstitial fluid system, mechanotransduction, cells durotaxis and mast cell degranulation. Chin Med 2009;29:4–10.
60. de Vernejoul P, Albarède P, Darras JC. Nuclear medicine and acupuncture message transmission. J Nucl Med 1992;33:409–412.
61. Kovacs F, Gotzens V, Garcia A, et al. Experimental study on radioactive pathways of hypodermically injected technetium-^{99}m. J Nucl Med 1992;33:403–407.
62. Dorsher PT. Myofascial referred-pain data provide physiologic evidence of acupuncture meridians. J Pain 2009;10:723–731.
63. Melzack R, Stillwell DM, Fox EJ. Trigger points and acupuncture points for pain: Correlations and implications. Pain 1977;3:3–23.
64. Chou LW, Hsieh YL, Kao MJ, Hong CZ. Remote influences of acupuncture on the pain intensity and the amplitude changes of endplate noise in the myofascial trigger point of the upper trapezius muscle. Arch Phys Med Rehabil 2009;90:905–912.
65. Takamoto K, Hori E, Urakawa S, et al. Cerebral hemodynamic responses induced by specific acupuncture sensations during needling at trigger points: A near-infrared spectroscopic study. Brain Topogr 2010;23:279–291.
66. Birch S, Felt B. Understanding Acupuncture. Edinburgh: Churchill Livingstone, 1999.
67. Birch S. Trigger point-acupuncture point correlations revisited. J Altern Complement Med 2003;9:91–103.

Address correspondence to:
Yong-Keun Lee, DDS, MSD, PhD
Moon Dental Hospital
187-51, Daejo-Dong, Eunpyung-Gu
Seoul 122-842
Korea

E-mail: ykleedm@gmail.com