Role of Osteopathic Structural Diagnosis and Osteopathic Manipulative Treatment for Diabetes Mellitus and Its Complications

Amy W. Johnson, DO
Jay H. Shubrook Jr, DO

From the Department of Internal Medicine at Indiana University in Indianapolis (Dr Johnson) and the Department of Family Medicine at the Ohio University Heritage College of Osteopathic Medicine in Athens (Drs Johnson and Shubrook), where Dr Shubrook is the Director of the Diabetes Fellowship and the Director of the Diabetes/Endocrine Care and Research Center at the Diabetes Institute.

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Address correspondence to Jay H. Shubrook Jr, DO, Associate Professor of Family Medicine, Grosvenor Hall, Ohio University Heritage College of Medicine, Athens, OH 45701-2979.

E-mail: shubrook@ohio.edu

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Osteopathic physicians have a unique opportunity to affect the US epidemic of type 2 diabetes mellitus (T2DM). Osteopathic physicians make up a disproportionately high number of primary care physicians who are on the front lines of managing T2DM. In addition, the unique training of osteopathic physicians allows them to direct additional diagnostic and treatment modalities toward the musculoskeletal complications of diabetes. The present review surveys the literature that explores the effects of osteopathic structural diagnosis of and osteopathic manipulative treatment for T2DM, as well as the management and prevention of complications. The authors reviewed the databases for PubMed, Google Scholar, and *The Journal of the American Osteopathic Association*. Although the available literature is limited, the authors identify areas in which osteopathic-focused research has shown benefits and in which future research should be directed.

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Type 2 diabetes mellitus (T2DM) has been called a global epidemic.[1] The Centers for Disease Control and Prevention[2] estimates that in the US population, 25.8 million people have diabetes (90% to 95% with T2DM) and more than 3 times that number have prediabetes. Less than 10% of people with diabetes will receive care from an endocrinologist.[3] The care of the majority of people with T2DM is therefore in the hands of primary care physicians. Although osteopathic physicians (ie, DOs) comprise 5% of all physicians, 56% of DOs practice primary care.[4] Thus, DOs represent a disproportionately high segment of primary care physicians,[5] and they often play a central role in the care of people with T2DM. This responsibility will become even more critical given that 1 in 3 US residents born in the year 2000 will eventually develop diabetes.[6]

The state of the current diabetes epidemic brings with it substantial financial costs. The Hastings Center[7] reports that 10% of all Medicare dollars are spent on people with diabetes. Further, in 2007 the cost of care in the United States for people with diabetes was estimated at $174 billion, with the greatest costs going toward managing complications.[8]

Current guidelines for the management of diabetes[9] recommend lifestyle modification and then a stepwise addition of medications. These efforts may temporarily improve glucose control, but they are not effective in stopping the progression of this serious disease. Data from A Diabetes Outcome Progression Trial (ADOPT)[10] and

the United Kingdom Prospective Diabetes Study (UKPDS)[11] clearly show that T2DM is a relentless and progressive metabolic disease that substantially impacts morbidity and mortality.[9,11,12]

Osteopathic manipulative medicine (OMM) is defined in multiple ways. The use of osteopathic structural diagnosis and osteopathic manipulative treatment (OMT) are 2 defining features that are recognized by most authorities as distinctive from allopathic medicine. Further, the focus on primary care—particularly the practice of preventive and "holistic" medicine—has also been considered a special feature of osteopathic medicine.[13]

Thus, DOs have the opportunity to approach the diagnosis and management of T2DM uniquely. The holistic preventive approach to this disease has been described previously by the present authors.[14] Few articles, however, have been published on the use of osteopathic structural diagnosis and OMT and its effects on the prevention and management of T2DM and its complications. The present article reviews the existing literature on this topic.

Methods

We searched online databases for literature that had already been published on this topic, including PubMed, Google Scholar, and *The Journal of the American Osteopathic Association* (*JAOA*). The following key words were used: *osteopathic medicine*, *osteopathic manipulative therapy*, *osteopathic manipulative treatment*, and *OMT*. Each of these key words was paired with *diabetes*. PubMed search results for *osteopathic medicine* and *diabetes* included 142 articles, but only 14 were directly related to osteopathic structural diagnosis and OMT in relation to T2DM and its complications. Searches for *OMT*, *osteopathic therapy*, and *osteopathic treatment* did not reveal any unique resources compared with the other terms. From Google Scholar, 1510 articles were found using the keywords *osteopathic treatment* and *diabetes*, but only 5 previously uncovered articles were identified (including textbooks and unpublished theses). We also reviewed the bibliographies of the aforementioned studies. A specific search in the *JAOA* for *osteopathic treatment* and *diabetes* revealed 42 results. However, no new original research was identified. We also searched within "The Somatic Connection"—the section of the *JAOA* that summarizes and discusses scientific literature around the world—but found no pertinent studies.

The studies tended to be small and had limited generalizability. Bearing in mind these limitations, we reviewed the current available literature, highlighting specific areas in which additional research is needed. However, detailed analysis of each study is beyond the role of the present exploratory review.

Osteopathic Palpation and Structural Diagnosis

Osteopathic physicians use palpatory findings of the musculoskeletal system to aid in the physical examination of their patients. These findings give DOs additional information regarding their patients. In addition, osteopathic medical students are taught and expected to know the viscerosomatic reflexes for each internal organ. For instance, the heart is innervated by thoracic sympathetic spinal levels 1 through 5 (T1-T5) and the pancreas is innervated by T5-T11.[15]

Such knowledge may also enable DOs to monitor for T2DM and its complications. Because of the dual innervation of viscera and somatic tissue, diseases may manifest as somatic dysfunctions (ie, "impaired or altered function of related components of the somatic [body framework] system: skeletal, arthrodial and myofascial structures, and their related vascular, lymphatic, and neural elements") or Chapman reflexes (ie, "a system of reflex points that present as predictable and anterior and posterior fascial tissue texture abnormalities [plaque-like changes or stringiness of the involved tissue] assumed to be reflections of visceral dysfunctions or pathology")

without other signs or symptoms.[16] Therefore, one could reasonably assume that patients with T2DM have abnormal reflexive spinal levels associated with the pancreas.

The viscerosomatic relationship was explored in a study by Licciardone et al[17] that evaluated 30 different palpatory criteria in 92 patients (30 control, 62 with T2DM). The authors found that patients with T2DM experienced tissue texture changes between T11 and L2 on the right side.[17] Interestingly, these changes were not detected at the level of the pancreas, but at the level of the right kidney. Licciardone et al[17] suggested that these findings may be attributed to the progression of disease, such as renal dysfunction, which may predict nephropathy. To support this theory one could state that T2DM is not simply a pancreatic disease but a multisystem disease of insulin resistance that manifests somatically throughout the body. As was eloquently described by DeFronzo,[18] diabetes was once regarded as strictly a disease of insulin deficiency and insulin resistance, but it is now recognized as a complex multisystem disease both in its etiologic process and its effects.

Changes in soft tissue and fascial structures over time may be the key to initial somatic manifestations. A 2010 pilot study[19] of 40 patients with diabetes found that palpation of subcutaneous tissues' turgidity in the posterior cervical spine could be a tool to determine the patient's blood sugar range. The degree of tissue texture changes was quantified subjectively and compared with random blood sugar levels. Patients with higher random blood sugar levels demonstrated increased tissue fullness and bogginess as demonstrated by 2 of 3 measurements that reached statistical significance. The findings suggested that increased fluid level shifts into the extracellular compartment were due to increased glucose levels. Whereas the sample sizes of fewer than 100 patients in the 2 previously mentioned studies[17,19] make statistical analysis limited, the results suggest that DOs can potentially use tissue palpation as a distinct physical examination tool specifically for patients with T2DM.

Body Awareness

Osteopathic physicians may observe that a patient who receives OMT will become more attuned to his or her body's functions and will often return to the clinic with complaints as specific as "My rib feels out today." We have witnessed this "side effect" numerous times in our OMM clinic. This increased awareness may not be limited to the musculoskeletal system.

Could OMT enhance what patients with T2DM already sense? Unlike other patients with chronic diseases, patients with T2DM already have a heightened awareness of subtle changes in their bodies. Might OMT attune them to more subtle autonomic, neuroglycopenic, hypoglycemic, or hyperglycemic changes—and thus know when glucose levels need to be monitored beyond the times recommended by their treating physicians? This adjustment might be made during times of stress, illness, or exercise, or when patients feel like they are "high" or "low." Patients need to be aware of how their bodies respond to blood sugar extremes because such spikes and drops can be fatal.

Unfortunately, patients are typically poor predictors of blood glucose levels based on their physical symptoms and mood.[20] Future studies could examine if people with diabetes who received OMT were more accurate in "feeling" their glucose level. This is important because glucose level monitoring is often underused. A recent study[21] showed that many patients—42% taking insulin and 50% not taking insulin—did not routinely check their glucose level or, when they did record their glucose levels, did not bring in these readings to the health care provider. Furthermore, 54% of insulin users did not use the information from a fingerstick glucose reading to determine their insulin dose.[21] Thus, the increased body awareness provided by regular OMT sessions could enable patients to expand their "disease awareness." With increased awareness comes the opportunity for patients to better manage their diabetes.

Body awareness therapy (BAT) is a physiotherapy used in Nordic countries that is "directed toward an

awareness of how the body is used, in terms of body function, behavior, and interaction with self and others."[22] By emphasizing some of the same aspects as OMM, such as posture and breathing, BAT builds a stronger relationship between the patient's body and self and thus allows the patient a more positive outlook of his or her body.[22] Fibromyalgia, chronic pain, and eating disorders are among the conditions that have been successfully managed by means of BAT.[23] Future studies could investigate the possible relationship between BAT and OMM and its implications in systemic disease.

Musculoskeletal Complications

Physicians often focus on microvascular and macrovascular complications of T2DM.[2] However, there are also musculoskeletal complications that cause profound physical disabilities in the later stages of T2DM. These include adhesive capsulitis (frozen shoulder), limited joint mobility of the hands, Dupuytren contracture, carpal tunnel syndrome, stenosing flexor tenosynovitis, diffuse idiopathic skeletal hyperostosis, and neuropathic (Charcot) osteoarthropathy.[24-28] Not all of these diseases are unique to T2DM, but diabetic patients are at increased risk compared with the general population (*Table*). Traditionally, management of these diseases involves invasive therapeutic options.

Limited joint mobility of the hands is a condition that often particularly affects the small joints. It is also known as *diabetic cheiroarthropathy*, although it can be diagnosed in patients without diabetes at an incidence rate of 0% to 26% compared with 8% to 75% in patients with T2DM.[24,25] This musculoskeletal manifestation substantially limits patients' activities of daily living and is usually managed by means of glycemic control, physiotherapy, and a diet rich in antioxidants.[28]

Dupuytren contracture is characterized as painless stiffness of the fingers or palm caused by digital or palmar thickening, tethering, and contracture of the finger and hands.[25,29] Patients with diabetes often have increased incidence (8% to 50% compared with 13% in patients without diabetes) and are more severely affected.[24] Treatment options include needle fasciotomy, collagenase injections, and, rarely, surgical manipulation.[30,31]

Diffuse idiopathic skeletal hyperostosis presents as a gradual onset of joint stiffness and pain. The condition typically affects the axial spine (rather than the appendicular joints) and manifests as new bone growth that connects previously independent bones.[24,32] The condition may be managed by means of glycemic control, analgesics, physiotherapy, and local corticosteroid injections.[28]

Another complication is stenosing flexor tendosynovitis, or "trigger finger," which presents as a pain in the finger coupled with a locked flexion or extension. The condition commonly involves the first, third, and fourth fingers.[28,29] Current treatment modalities include activity modification, nonsteroidal medications, corticosteroid injections, and surgical manipulation.[24,25]

Adhesive capsulitis, an acute painful restriction in range of motion in the shoulders, has an approximately 5-fold greater incidence in patients with T2DM than in the general population.[25] The current standard for managing this condition includes analgesics, corticosteroid injection, or physiotherapy. Surgical manipulation is the option most often used with refractory cases.[27]

Carpal tunnel syndrome is the entrapment of the median nerve within the carpal tunnel, resulting in pain, paresthesias, and numbness in the first, second, and half of the third digits of the hand. The syndrome's effects can also involve the entire hand, up to the elbow, and even the shoulder.[25] Conventional treatment options include eliminating the causative motions, rest, immobilization, corticosteroid injections, and surgical release of the transverse carpal ligament, depending on the severity.[33]

Finally, neuropathic (Charcot) osteoarthropathy is a disorder of progressive joint and bone damage usually affecting ankle and small foot joints. The disorder can be attributed mostly to diabetic neuropathy but can be found in patients without diabetes.[25] It is typically managed

with early immobilization, use of orthotics or crutches, and occasionally surgical correction.[32,34]

Osteopathic Management of Musculoskeletal Complications

The current management options for many of the aforementioned musculoskeletal complications involve physical therapy, nonsteroidal anti-inflammatory drugs, local injection with corticosteroids, and surgical manipulation; the latter 2 involve substantial risks for patients with T2DM. Kallock et al[35] observed that the use of corticosteroid injections can transiently increase blood glucose levels for several days in patients with controlled diabetes. Patients with T2DM may also experience increased postoperative morbidity and mortality due to exaggerated stress response, altered glucose regulation, and a possibly increased thrombotic state. A study by Siu et al[33] reported an increase in mortality by as much as 42% following major surgical procedures, such as coronary bypass surgery mortality in patients with T2DM.

Osteopathic manipulative treatment is another potential adjunctive means of managing T2DM complications. Although limited, the osteopathic literature regarding T2DM and OMT is promising. A 1949 study by Bandeen[36] even indicated that OMT may lower glucose levels in people with hyperglycemia and increase insulin secretion from the pancreas. Although specific trials have not been completed for all the mentioned musculoskeletal complications of T2DM, the principles of restricted range of motion of any joint can essentially be applied to each.

A review of the older osteopathic literature by Dagogo-Jack and Alberti[37] reported mixed results in addressing hyperglycemia. Depending on the technique, OMT has been shown to both increase and decrease blood glucose levels. Specifically, rib raising focused at the second through fifth ribs ("pancreatic stimulation") was found to decrease blood glucose levels at 30 minutes and at 60 minutes; rotary manipulation of T11-T12 and L1 ("pancreatic inhibition") resulted in increased levels of glucose at the same time intervals.[35] The results from the study of Kallock et al[35] raised the possibility that OMT can be used to affect blood glucose levels. Several studies,[33,38-40] which we will describe later in this review, have also documented the effectiveness of OMT in managing diabetic musculoskeletal complications.

The effects of OMT on carpal tunnel syndrome have been the most studied to date. Siu et al[33] showed that OMT can be used effectively as an adjunct to traditional therapies for CTS. Sucher et al[38] showed that OMT can increase the width of the transverse carpal arch using 3-dimensional video and precision calipers analysis on cadavers, resulting in an initial increase of 13% in length with a 9% residual increase. Further, Sucher[39] had previously used magnetic resonance imaging of the wrist to reveal that both the anterior and posterior dimension of the tunnel are increased with OMT. There is even a treatment modality—introduced by William Sutherland, DO,[40] a student of Andrew Taylor Still, MD, DO—that uses ligamentous articular strain techniques: carpal tunnel treatment, which focuses on the wrist and the entire upper extremity, the upper rib cage, and the cer-

Table.
Prevalence of Musculoskeletal Manifestations in the General Population vs Patients With T2DM, %

Musculoskeletal Manifestation	General Population	Patients With T2DM
Limited joint mobility of the hands[22,23]	0-26	8-76
Dupuytren contracture[22]	16	20-63
Diffuse idiopathic skeletal hyperostosis[22]	1-13	13-49
Flexor tenosynovitis[22,23]	1-2	5-36
Adhesive capsulitis[22,24,25]	2-10	11-33
Carpal tunnel syndrome[22,24]	1	11-25
Neuropathic osteoarthropathy[23,26]	0.1-0.4	0.1

Abbreviation: T2DM, type 2 diabetes mellitus.

vical and thoracic spines. Carpal tunnel treatment exemplifies the holistic approach of OMT, addressing the systemic nature of what appears to be a local dysfunction. These studies[33,38-40] should be expanded and replicated to build the evidence base for OMT for carpal tunnel syndrome.

A case report by Sampson et al[30] demonstrated the use of OMT as adjunct therapy in managing Dupuytren contracture. The patient presented with decreased ability to extend her fourth and fifth fingers bilaterally. After 5 weekly sessions with ultrasonography-guided lidocaine injections, needle aponeurotomy, and OMT, the patient recovered full range of motion in her hand. An 8-week follow-up ultrasonographic image revealed reduced nodularity and scarring of the affected tendons compared with the nodularity and scarring at the initial patient visit. Because this case study involved multimodal management, it is unclear whether 1 modality or a combination of modalities was more beneficial. Follow-up clinical trials should be designed to compare the treatment modalities with each other, as well as with placebo.

Heinking[41] and Knebl et al[42] have reported on the use of OMT for adhesive capsulitis. To manage this condition, Heinking[41] recommended OMT for the upper thoracic area, the upper ribs, and the shoulder complex. Knebl et al[42] demonstrated the effectiveness of OMT in increased range of motion in the shoulder complex that could also be used for adhesive capsulitis. The use of OMT in managing adhesive capsulitis shows promise, and we believe that future osteopathic research should focus on this topic.

Additional randomized, controlled trials are still needed before OMT can be confirmed as a lone alternative to standard therapies for musculoskeletal complications of T2DM. Studies need to evaluate OMT vs standard therapies, as well as OMT vs adjunct therapy or vs standard therapies alone. This area, too, is ripe for future research.

Prevention of T2DM Complications

Osteopathic palpatory techniques may allow DOs to detect subtle increases in restriction, which in turn may help DOs diagnose early-onset musculoskeletal manifestations. Along with a targeted medical history, a physical examination is crucial for diagnosis. In Dagogo-Jack and Alberti's review[37] of carpal tunnel syndrome, the use of osteopathic palpation and structural diagnosis was shown to assist in diagnosis of the condition and monitoring it for improvement and recurrence. Restriction of motion within the carpal tunnel, shoulder, and axial spine can easily be assessed with a thorough osteopathic structural examination. Two key factors involve clinical intuition: (1) making sure the DO first monitors for such findings and (2) performing or refering a patient for OMT as soon as restricted motion is detected.

Performing OMT can delay the onset or even prevent alterations in mobility and range of motion in the upper extremity.[41] For example, the Spencer technique improved functionality in an elderly population by increasing shoulder range of motion.[42] The Spencer technique is a 7-step articular OMT procedure that addresses shoulder pain and restriction, paying particular attention to the glenohumeral and scapulothoracic joints.[43]

Finally, patients with T2DM who have concomitant limited joint mobility were found to have a higher incidence of retinopathy and nephropathy and had greater insulin requirements than diabetic patients without limited joint mobility.[25] Thus, having a higher index of suspicion for the musculoskeletal manifestations and using osteopathic structural diagnosis and OMT to uncover earlier tissue restrictions and manage those restrictions accordingly could have an impact on somatic complications and even microvascular complications.

Future Directions for an Osteopathic Approach to T2DM

In addition to randomized, controlled trials that investigate OMT as primary or adjunctive therapy, future studies should evaluate outcomes such as effects on range of motion and quality of life. Studies using spinal level associations and tissue texture abnormalities can also be conducted to determine if musculoskeletal manifestations can be diagnosed early and if treatment can delay the onset of other complications from T2DM.

Specifically, we would like to see additional research that addresses osteopathic viscerosomatic reflexes in T2DM, that evaluates the use of OMT to raise body awareness to help identify dysglycemia, and that focuses on the use of OMT to manage the musculoskeletal complications of T2DM, such as adhesive capsulitis and limited joint mobility.

Conclusion

The literature that we reviewed strengthens the case for osteopathic structural diagnosis and OMT in the screening for and management of musculoskeletal complications from T2DM. Although small and limited in scope, these studies should form the foundation for further exploration, and the present review points future researchers to the areas in which the science can be bolstered and in which osteopathic research can contribute to this field. In the meantime, we suggest that a priority be placed on the areas of research that provide evidence of effectiveness of osteopathic principles and practice, as well as OMT, in the management of chronic systemic disease.

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