Osteopathic Manipulative Treatment Affects Renal Mobility and Blood Pressure: A Preliminary Study

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Abstract

Introduction: Based on the osteopathic principle that "structure and function are interrelated," a kidney that is not moving optimally with respiration might be limited in its physiologic functions as well. The objective of this study was to determine if osteopathic manipulative treatment (OMT) affects craniocaudal renal mobility and if there are any correlations between renal mobility and blood pressure measurements.

Methods: 33 healthy female participants were recruited. 25 participants were in the treatment group, and 8 in the control group. All participants' blood pressures were recorded initially. All participants were then evaluated for craniocaudal renal mobility via ultrasound measurements using Mindray Z6 technology. The treatment group then received an OMT protocol, while the control group rested for 20 minutes. The ultrasound evaluation for renal mobility was then repeated on the participants, and a final blood pressure reading obtained (Touro College HSIRB #1799).

Results: OMT significantly increased the mobility of the right kidney ($P<0.05$), but not the left kidney. Although there was no direct correlation between changes in renal mobility and changes in blood pressure, both the systolic and diastolic blood pressure readings decreased significantly ($P<0.05$) after OMT.

Conclusion: In this preliminary study, right kidney mobility increased and systolic and diastolic blood pressure measurements both decreased after OMT. Follow-up studies are warranted to further explore kidney mobility and its potential association with blood pressure measurements, as well as the effects of OMT on kidney mobility and blood pressure.

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Introduction

Kidney function plays a major role in maintaining body homeostasis. Each kidney filters 1 to 1.5 liters of blood daily, and manages fluid levels, electrolyte balance, pH stability, and waste excretion. The kidney produces erythropoietin to stimulate bone marrow red blood cell production, and calcitriol to increase calcium absorption in the intestine and phosphate reabsorption in the kidney. Additionally, the kidney produces renin, which controls blood pressure via the renin-angiotensin system.[1]

Anatomy

The kidneys are situated retroperitoneally on the posterior abdominal wall at the level of the T12 to L3 vertebrae. The right kidney is slightly lower than the left, due to the presence of the liver.[2] The kidneys are surrounded by the diaphragm superiorly, the psoas and the quadratus lumborum muscles inferoposteriorly, and the gastrointestinal organs and the spleen anteriorly. There are slight impressions on the kidneys caused by their contact with neighboring muscles, tendons, the 12th ribs, and the lumbo-costal arch. These impressions are more prominent on the left kidney, which also tends to be larger and heavier than the right kidney. The left renal artery is shorter than the right, although its vein is longer. A common morphological variation of the left kidney is a lateral "bulge" due to the left kidney being weighed down by the spleen, which has been described as the

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left kidney "having to carry the spleen on its back." The liver is located more ventrally than the spleen, so it does not burden the right kidney in the same way.[3]

The kidneys are concave medially, where the renal sinus is located. The sinus holds fat with the renal pelvis, calyces, blood, and lymphatic vessels, and nerves. Each kidney's outer capsule is surrounded by perirenal fat and the renal fascia. Pararenal fat surrounds the outside of the renal fascia. These fat layers accommodate movement of the kidney during respiration.[2]

The anterior portion of the renal fascia extends in front of the kidney and its vessels to merge with the connective tissue enclosing the aorta and inferior vena cava. The posterior layer passes between the kidney and the fascia on the quadratus lumborum and psoas major muscles, attaching to this at the lateral and medial borders of the psoas, as well as the lumbar vertebrae and intervertebral discs. Above the adrenal glands, these two layers of renal fascia fuse and become continuous with the diaphragmatic fascia. Inferior to the kidneys, these layers remain separate - the anterior blending into the extraperitoneal fascia of the iliac fossa, and the posterior blending with the iliac fascia. The kidney is partly held in place by the renal fascia, as well as the apposition of neighboring viscera.[4]

Renal Mobility

Abdominal organs demonstrate significant respiratory-induced mobility, likely due to their proximity to the diaphragm.[5,6] The kidney moves caudally with inspiration and in the cranial direction with exhalation. The kidney also moves anteroposteriorly and rotates transversely as well. Kidney craniocaudal mobility during quiet respiration has been recorded to be between 11 mm and 18 mm on ultrasound and CT scans,[5,7] while Abhilash et al similarly recorded 17.06 mm to 24.54 mm kidney mobility via ultrasound imaging. Average craniocaudal displacement of the kidney with deep, forced respiration is 40 mm, with a range of 20-70 mm.[7] Abhilash et al found that, on average, the right kidney has more mobility than the left on deep breathing ultrasound imaging. Schwartz et al, however, studied renal mobility with magnetic resonance imaging and demonstrated that in deep inspiration or deep expiration, the positions of the right and left kidneys appear similar.[8] Van Sornsen de Koste et al did not find a significant difference between the sexes, although there was interparticipant variability in their study using 4D CT scans. Kidneys affected with calcified cysts, polycystic disease, angiolipomas or carcinomas had decreased mobility,[6] as did patients with low back pain, when compared to normal participants.[7]

Altered positioning of the kidney can affect its renal and vascular function. For example, nephroptosis, the descent of the kidney on imaging studies by greater than 5 cm or 2 vertebral bodies in the erect position,[9] is implicated as a cause of hypertension and fibromuscular dysplasia of the renal artery.[10-12] Nephroptosis is also associated with decreased glomerular filtration rate in the erect posture.[13] This increased mobility of nephroptosis, also known as a "floating kidney," is more frequently encountered on the right than on the left side.[3]

Changes in renal mobility could have implications on renal function. Based on the osteopathic principle of "structure and function are reciprocally inter-related,"[14] the kidney that is not moving optimally with respiration might be limited in its physiologic functions due to altered neurovascular and lymphatic exchange.[14] The level of diaphragmatic movement influences the displacement of the kidneys.[15] If there is reduced respiratory excursion of the diaphragm, either from muscle hypertonicity of the quadratus lumborum and/or the psoas via the arcuate ligament attachments, then the kidney mobility will be expected to be reduced. The restricted mobility may negatively affect all of the kidney's physiologic functions, including the renin-angiotensin system, and thus contribute to hypertension.

We hypothesize that applied OMT will improve craniocaudal renal mobility as measured by ultrasound. Additionally, we hypothesize that kidneys that are limited in craniocaudal mobility will be associated with increased blood pressure readings.

Methods

Ethical approval was obtained from the institutional review board at Touro College of Osteopathic Medicine before data collection began (Touro College HSIRB# 1799).

Participants

Participants included college students, faculty, staff and extended college community members. The participants were healthy, non-pregnant females, ages 22 to 55 years old. Females were chosen for this study because it has been established that females have greater renal mobility than males and to control the variables.[12] Participants were not using anti-hypertensive medications or any other medications that might be primarily metabolized by the kidney. The participants did not have a kidney transplant or an active diagnosis of cancer. The participants all signed informed consents.

Procedure

1. All participants' blood pressures were recorded initially, while seated, using the left arm for the blood pressure readings.
2. All participants were then evaluated for renal mobility via ultrasound measurements using Mindray Z6 technology (see Ultrasound Protocol).

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3. The treatment group and control group.
    a. The Treatment group (n=25) received an osteopathic evaluation and OMT for no longer than 20 minutes (see OMT Protocol.)
    b. The control group (n=8) did not receive OMT. They were asked to lie in a supine position for 20 minutes.
4. The participants then underwent another evaluation for renal mobility via ultrasound (see Ultrasound Protocol).
5. The participants had a final blood pressure reading recorded, as above.

Ultrasound Protocol

- The participant was in prone position.
- The ultrasound probe was placed on the posterolateral aspect of the left trunk.
- Kidney mobility (KM) for the left kidney (LK) was obtained by:
    - measuring the distance traveled by the superior renal pole of the LK during inhalation; this was measured as the distance between the superior pole of the LK and a fixed point on the ultrasound image, both at rest and during maximal inhalation.
        - Max Insp LK – Rest LK = ΔIns LK
    - measuring the distance traveled by the superior renal pole of the LK during exhalation; this was measured as the distance between the superior pole of the LK and a fixed point on the ultrasound image, both at rest and during maximal exhalation.
        - Rest LK – Max Exp LK = ΔExp LK
        - ΔIns LK + ΔExp LK = KM_LK
- The ultrasound probe was placed on the posterolateral aspect of the right trunk.
- KM for the right kidney (RK) was obtained as above for the LK.
    - ΔIns RK + ΔExp RK = KM_RK

This ultrasound screening was done pre-OMT and post-OMT for the treatment group, and pre-rest and post-rest for the control group to determine Pre-KM_LK, Pre-KM_RK, Post-KM_LK and Post-KM_RK (Figures 1 and 2).

OMT Protocol

The following techniques were applied bilaterally in the following order to the specified regions to address individual dysfunctions at those regions. Except for the rib technique, the participant was lying supine (Table 1).

Figure 1. RK maximal inspiration

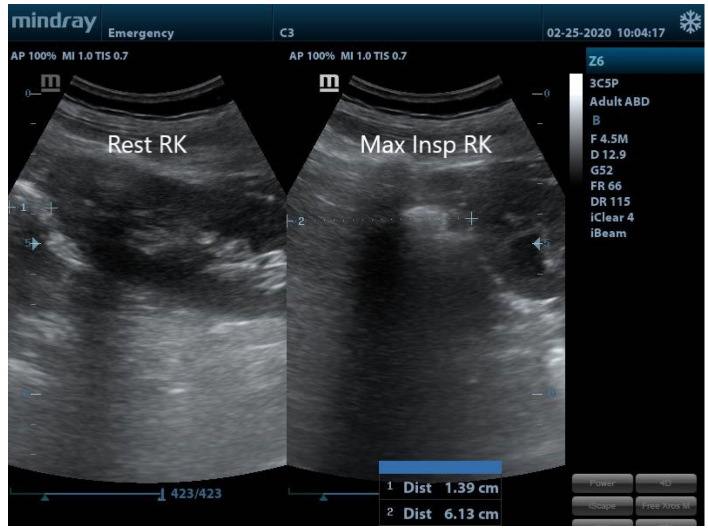

Figure 2 RK maximal expiration

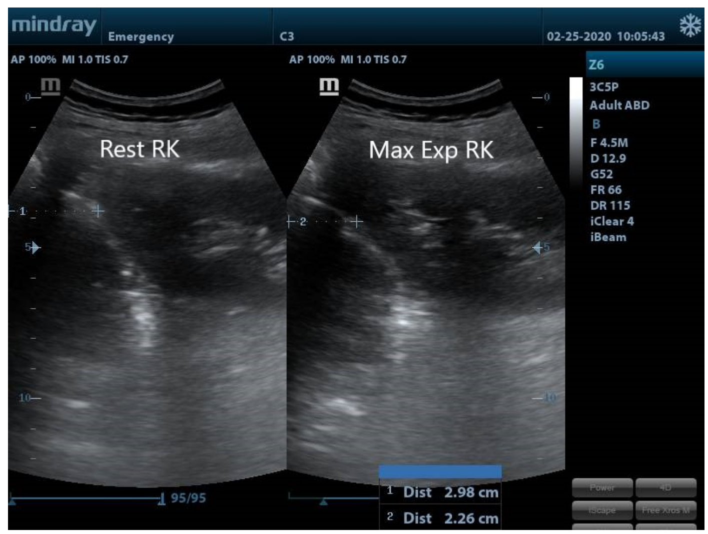

Table 1 OMT Protocol

	Region	Technique
1	Ribs	Seated articulatory technique of all ribs
2	Lower Extremity	Muscle energy to the hip and myofascial release (direct).
3	Sacro-iliac joints	Articulatory technique
4	Quadratus Lumborum	Myofascial articulatory technique as described by Ken Lossing DO*
5	Abdomen	Myofascial release of the diaphragm (direct)
6	Occipito-atlantal joint	Condylar decompression

*Physician places closed fist with thenar eminence just below the 12th rib on the quadratus lumborum muscle and lifts anteriorly to engage myofascial tension in a direct manner. The other hand grasps the flexed ipsilateral knee and brings the hip into a flexion-abduction-extension-internal rotation maneuver while maintaining the anterior tension on the quadratus lumborum as a fulcrum.

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Statistical Analysis

Analysis was conducted using Excel T Test, tail 1, type 1 (Table 2).

Table 2 – Paired Comparisons

T-Test, tail 1, type 1 comparisons	P value
Pre- and post-systolic blood pressure – treatment group	0.0001
Pre- and post-diastolic blood pressure – treatment group	0.0263
Pre- and post-systolic blood pressure – control group	0.4436
Pre- and post-diastolic blood pressure – control group	0.3341
Pre- and post-KMS right kidney – treatment group	0.0160
Pre- and post-KMS left kidney – treatment group	0.2721
Pre- and post-KMS right kidney – control group	0.1746
Pre- and post-KMS left kidney – control group	0.2636

Results

The right kidney mobility increased by an average of 0.841 cm after OMT (pre-KM_RK 4.712 cm and post-KM_RK 5.553 cm), with a statistical significance of p= 0.016. The left kidney mobility did not change significantly after OMT (average pre-KM_LK 3.996 cm and post-KM_LK 4.176 cm with p=0.272) *(Figures 3 and 4)*.

The control group did not show any significant changes. The right kidney mobility initially averaged 5.615 cm before rest, and 5.145 cm after rest, with a p-value of 0.175. The left kidney mobility average was 4.728cm before rest and 4.965cm after rest, with a p-value of 0.264 *(Figures 5 and 6)*. A small portion of the recorded measurements of kidney mobility resulted in a decrease in measured cranio-caudad excursion.

Of the participants, 28 were less than 30 years old, and 5 were between the ages of 30 and 45 years old. Age did not seem to correlate with kidney mobility in this preliminary study *(Figure 7)*.

There was no association evident when comparing initial blood pressure measurements with kidney mobility. *(Figure 8)*.

There was a statistically significant decrease in the systolic blood pressure readings after osteopathic treatment (p=0.0001). The treatment group's diastolic blood pressure readings also decreased (p=0.0263). The control group's systolic and diastolic blood pressure readings were not significantly different before and after the rest period (p=0.4436 and p=0.3341 respectively) *(Figure 9)*.

Figure 3. *Effect of OMT on Right Kidney Mobility*

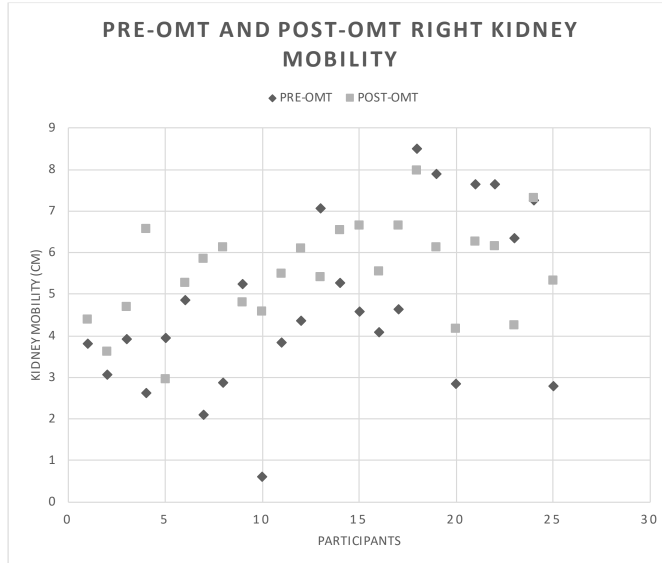

Figure 4. *Effect of OMT on Left Kidney Mobility*

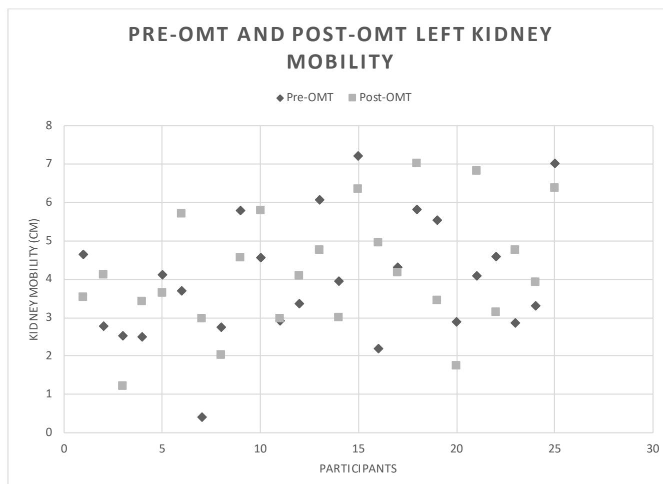

Figure 5. *Effect of 20 minute rest on right kidney mobility*

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Figure 6. *Effect of 20 minute rest on left kidney mobility*

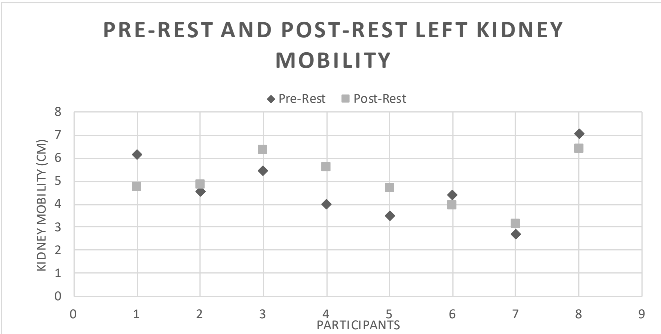


Figure 7. *Age and Kidney Mobility*

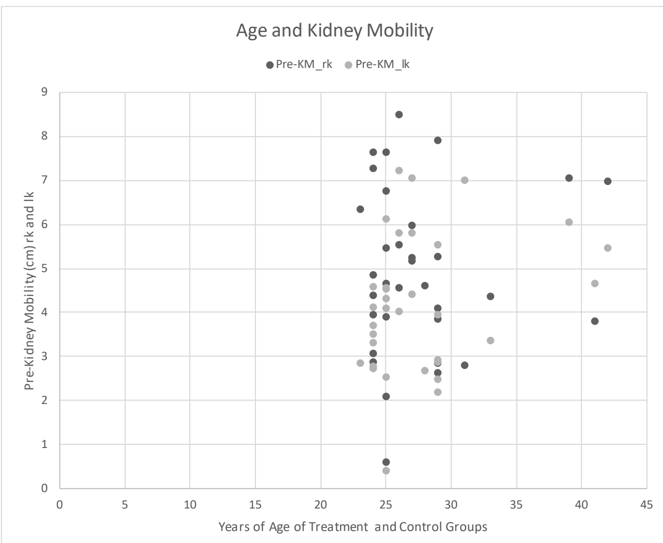
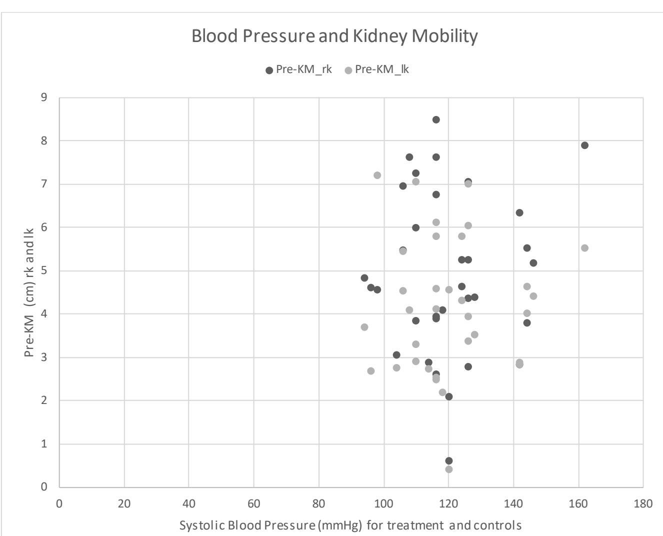


Figure 8. *Blood Pressure and Kidney Mobility*



Discussion

OMT and Kidney Mobility

OMT significantly changed the right kidney mobility, but not the left. Abhilash et al found more mobility with deep breathing in the right kidney compared to the left. The left kidney seems to be more fixed than the right, perhaps due to its larger size, and it might be more securely anchored by its shorter renal artery.[3] The right kidney's increased mobility might allow regional somatic dysfunctions to have a greater negative influence on its mobility, which in turn allows for more improvement after OMT. Of interest, a minority of observed outcomes had a decrease in kidney mobility after OMT. This may be due to variability in ultrasound measurements. Measuring renal mobility in the prone position limited the intraparticipant variability we found in our measurements. Perhaps this is due to reduced movement of the probe in the prone position due to abdominal respiratory movement. Nephroptosis could account for some of these negative values. In the future, adding upright measurements in the ultrasound protocol prior to the prone measurements could help detect nephroptosis.

Blood Pressure and Kidney Mobility

Most participants (20 out of 33) had normal blood pressure readings, with a systolic blood pressure less than or equal to 120 mmHg. There were 7 participants who demonstrated blood pressure readings between 124 mmHg and128 mmHg, and 5 participants had blood pressure readings between 142 mmHg and 146 mmHg, while 1 participant had a reading of 162 mmHg. There was not enough variability in the blood pressure measurements to explore a potential association between kidney mobility and blood pressure measurements. Future studies with larger participant sample size with broader age ranges would help demonstrate potential associations.

Blood Pressure and OMT

Systolic and diastolic blood pressure readings significantly decreased after OMT. Hypertension affects and is affected by all systems, including the cardiovascular, neurologic, renal, and musculoskeletal systems. Johnston et al demonstrated a C6, T2, T6 predictable pattern of segmental dysfunction associated with hypertension.[16,17] A majority of hypertensive patients present with paravertebral tissue texture changes in the thoracolumbar region. This might be due to viscerosomatic reflex changes involving the kidneys.[18] Historically, the osteopathic medical profession has described various neuromusculoskeletal findings associated with hypertension. Louisa Burns used human and animal models to study somatovisceral and viscerosomatic spinal reflexes. She demonstrated that stimulation or inhibitory pressure on the somatosensory nerves of the thoracic muscles, tendons and joints affects visceral function. Burns demon-

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strated that inhibitory pressure of the upper thoracic region resulted in lower systolic blood pressure and lower pulse rate.[19,20] There are a number of studies demonstrating improvements in hypertension with OMT. Burns, Northup, Blood, Downing and Norris demonstrated that OMT can decrease elevated blood pressure readings.[19,21-24]

This preliminary study did not consider individual somatic dysfunctions beyond the protocol, nor did it address the C6, T2, T6 pattern. The protocol of OMT applied focused mostly on the renal fascial connections. This protocol might have affected the autonomic innervation of the heart and peripheral vasculature. Coronary arterial pressure and heart rate are controlled by the sympathetic and parasympathetic nervous system interaction. Treating the atlanto-occipital joint might have affected the vagus nerve and its parasympathetic influence, as it emerges from the medulla and exits the skull via the jugular foramen. The rib articulatory technique might have affected the sympathetic innervation to the cardiac plexus.[18,24] The myofascial techniques applied to the quadratus lumborum and the diaphragm, as well as the rib articulation of the lower ribs, might have affected the thoraco-lumbar junction and improved renal and splanchnic outflow.[18]

Limitations

The protocol in this preliminary study did not account for ptosis of the kidney. This could be a potential explanation for the decrease in kidney mobility measured after OMT in some participants. Taking additional ultrasound measurements of kidney mobility while in the standing position might account for ptosis in future studies. The limited number of participants, particularly in the control group, is a limitation in this study. Ultrasound measurement variability with deep breathing is another limitation. Breath holding at the end of inspiration demonstrates more cranial diaphragmatic displacement than end expiration breath holding,[25] which can affect the measurements. Varied respiratory effort put in by different participants affected inspiratory and expiratory measurements. Also, the ultrasound probe compression itself might be changing the respiratory movement. Inferior pole kidney measurements were not obtained, so potential changes in dimensions of the kidney overall were not mentioned or accounted for.

Sham OMT could be considered for the control group in future studies. However, sham OMT has been shown to have a clinical benefit compared to no treatment and is ideally suited for subjects who are naïve to OMT.[26]

Even with the aforementioned limitations, this preliminary study presents a foundation for future studies to explore kidney mobility and osteopathic manipulative treatment, as well as the potential relationship of kidney mobility and blood pressure measurements.

Conclusion

In this preliminary study, the clinical significance of osteopathic structural and functional relationships was shown with increased right kidney mobility and reduced systolic and diastolic blood pressure measurements after OMT. Follow-up studies are warranted to further explore the role of OMT and its effect on kidney mobility and blood pressure.

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