Correspondence and Communications

Wrist to forearm ratio as a median nerve shear wave elastography test in carpal tunnel syndrome diagnosis

Dear Sir,

Shear wave elastography (SWE) is an operator-independent, developing form of ultrasound examination. It measures tissue elasticity by tracking shear wave velocity. In tissues of greater stiffness, shear waves travel faster.\(^1\) The median nerve in carpal tunnel syndrome (CTS) is entrapped influencing its elasticity; therefore, SWE can become an accessible screening test in CTS diagnosis.

After preliminary observations, we found that the median nerve stiffness in CTS patients and in healthy population varies among individuals of different weight and gender. Therefore, we hypothesized that the ratio of nerve elasticity between the wrist and proximal nerve segment can serve as a more accurate reference value than a direct comparison to the healthy control. The aim of the study was to evaluate the diagnostic accuracy of the ratio of nerve stiffness in CTS.

The study protocol was approved by the University Bioethical Committee and performed according to the principles of the Helsinki Declaration. Patients in the university hospital with symptoms of CTS were invited. Idiopathic CTS was confirmed through nerve conduction studies. The severity of CTS was classified according to the AAEM\(^2\) criteria. Healthy volunteers that had CTS ruled out through nerve conduction studies were included in the control group. The exclusion criteria were: history of hand surgery, or hand injuries and recurrent CTS.

Carpal tunnel ultrasonography and SWE were performed on Toshiba iAplio 900 ultrasonograph with a 5-18 MHz transducer (Toshiba Medical Systems, Nasushiobara, Japan) by a radiologist who was unaware of the nerve conduction study results. Measurements of the nerve cross-sectional area (CSA) and SWE were performed at the level of the proximal carpal row and 12 cm and 20 cm proximally on the forearm (sites 1 and 2 respectively). The relevant wrist to forearm stiffness ratios 1 and 2 were measured.

Normal distribution was verified with the Shapiro-Wilk test. Intergroup comparisons of continuous variables were performed with the Mann-Whitney U test, and Kruskal-Wallis test, with Dunn post-hoc tests. Differential analysis of the diagnostic accuracy of elastography and CSA in CTS and control groups were performed with the receiver operating characteristic curve (ROC). For each of the analyzed predictors, its sensitivity and specificity, PPV and NPV, and the area under the ROC curve (AUC) were calculated along with a 95% confidence interval (95% CI). All calculations were performed using the Statistica 10 package (StatSoft, Tulsa, USA), with a threshold of significance set at \(p \leq 0.05\).

121 wrists were available for the study. CTS was diagnosed in 87 (72%). The absence of CTS was confirmed in 34 (28%). Patients with CTS were characterized by significantly higher nerve stiffness at the wrist. Values of nerve stiffness ratios 1 and 2 were higher in patients than in the control group (Table 1). Statistically significant positive correlations were also found between nerve CSA and its stiffness at the wrist (\(R = 0.54; \ p < 0.001\)), as well as between nerve CSA and stiffness ratios 1 and 2 (\(R = 0.42, \ p < 0.001\), and \(R = 0.43; \ p < 0.001\)). However, no correlations were found between CTS severity and nerve stiffness, or severity and CSA.

ROC analysis showed that for the differentiation of neuropathic and non-neuropathic patients a minimal stiffness value of 79 kPa at the wrist provided 96.6% sensitivity, 100% specificity, 100% PPV, and 91.9% NPV. Equally good diagnostic accuracy parameters were obtained for stiffness coefficients 1 and 2 amounting to 1.483 and 1.508, respectively (Table 2).

Results of the median nerve SWE were also described by Kantarci et al.\(^3\) These authors reported that mean nerve elasticity in patients is 66.7 kPa, and the cut-off value for nerve stiffness at the wrist is 40.4 kPa. Interesting differences between those observations and ours were noted in healthy subjects. Mean nerve stiffness in our control group was higher than Kantarci et al. (43.6 kPa and 32 kPa respectively), however, the range of our normal values (24-76 kPa) was very heterogeneous. In all our controls, CTS was excluded by electrophysiological examination, therefore this heterogeneity seemed physiological. We believe that it supports the idea of using wrist-forearm ratios instead of referring to an established norm at the wrist. Similar ratios between wrist to forearm CSA\(^4\) or CSA and nerve strain\(^5\) were proposed in order to overcome the diagnostic limitations of various ultrasonography techniques.

In conclusion we observed that the cut-off value of nerve stiffness was almost twice as high as that proposed by Kantarci et al. (79 kPa and 40.4 kPa respectively). In both works, however, a small number of participants could influence the results. We therefore propose to use a ratio of 1.48 instead of referring to the healthy norm. Wrist to forearm ratios seems to be independent of patient age or weight and exhibit excellent diagnostic accuracy regardless of where on the forearm the second measurement is taken.
Table 1  Comparison of the elastographic characteristics of the median nerve depending on the confirmation or exclusion of CTS diagnosis in nerve conduction studies.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cases with CTS (n = 87)</th>
<th>Control group (n = 34)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve stiffness in the wrist (kPa)</td>
<td>Median 100, Range 35-135</td>
<td>Median 42, Range 24-76</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nerve stiffness proximally in site 1 (kPa)</td>
<td>Median 47, Range 26-78</td>
<td>Median 43.5, Range 28-69</td>
<td>0.039</td>
</tr>
<tr>
<td>Nerve stiffness proximally in site 2 (kPa)</td>
<td>Median 49, Range 32-75</td>
<td>Median 44, Range 26-70</td>
<td>0.018</td>
</tr>
<tr>
<td>Stiffness coefficient 1</td>
<td>Median 2.1, Range 1.0-3.7</td>
<td>Median 1.0, Range 0.9-1.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Stiffness coefficient 2</td>
<td>Median 2.1, Range 0.9-3.8</td>
<td>Median 1.0, Range 0.8-1.1</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Nerve stiffness in sites 1 and 2 = stiffness in two sites proximally in the forearm; Nerve stiffness coefficient 1 = nerve stiffness in the wrist/nerve stiffness in site 1; Nerve stiffness coefficient 2 = nerve stiffness in the wrist/nerve stiffness in site 2.

Table 2  Diagnostic accuracy of the elastographic parameters of the median nerve in the differentiation between CTS patients and the control group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cut-off value</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>AUC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve stiffness in the wrist (kPa)</td>
<td>79</td>
<td>0.966</td>
<td>1.000</td>
<td>1.000</td>
<td>0.919</td>
<td>0.988 (0.971-1.000)</td>
</tr>
<tr>
<td>Nerve stiffness in site 1 (kPa)</td>
<td>30</td>
<td>0.989</td>
<td>0.088</td>
<td>0.735</td>
<td>0.750</td>
<td>0.621 (0.505-0.736)</td>
</tr>
<tr>
<td>Nerve stiffness in site 2 (kPa)</td>
<td>32</td>
<td>1.000</td>
<td>0.118</td>
<td>0.744</td>
<td>1.000</td>
<td>0.638 (0.521-0.756)</td>
</tr>
<tr>
<td>Stiffness coefficient 1</td>
<td>1.483</td>
<td>0.977</td>
<td>1.000</td>
<td>1.000</td>
<td>0.944</td>
<td>0.991 (0.976-1.000)</td>
</tr>
<tr>
<td>Stiffness coefficient 2</td>
<td>1.508</td>
<td>0.977</td>
<td>1.000</td>
<td>1.000</td>
<td>0.944</td>
<td>0.983 (0.959-1.000)</td>
</tr>
</tbody>
</table>

Nerve stiffness in sites 1 and 2 = stiffness in two sites proximally in the forearm; Nerve stiffness coefficient 1 = nerve stiffness in the wrist/nerve stiffness in site 1; Nerve stiffness coefficient 2 = nerve stiffness in the wrist/nerve stiffness in site 2.

Conflict of interest and funding

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Ultra-high frequency ultrasound in planning capillary perforator flaps: Preliminary experience

Dear Sir,

The introduction of perforator flaps has revolutionized the modern reconstructive plastic surgery. The technical ability to dissect small vessels allowed to further expand the perforator flap concept to precise composite tissues harvest, known as chimerism. The latest evolution of perforator flap was represented by the introduction of superthin skin flaps which are based on very peripheral vascular structures. Although the thinning procedure was usually performed after traditional harvest of adipocutaneous perforator flap, recently, Hong JP introduced the concept of harvesting thin flap by using superficial fascia as dissection plane thus allowing to directly harvest thin flaps. Moreover, a growing evidence is coming out on the reliability of smaller perforators also called “capillary” perforator in sustain skin flap metabolic demand, which may further expand reconstructive freedom and reduce morbidity. The term “capillary perforators” was introduced by Koshima in 2010 for defining perforators of 0.5 mm in caliber, which show no visible pulsation. The term “capillary” is intended as adjective to

Figure 1 (Above) Intraoperative picture of Superficial Circumflex Iliac Artery Perforator flap harvest based on two capillary perforators and a subdermal venule connecting with the superficial circumflex iliac vein. (Below) Preoperative planning using ultra-high frequency ultrasound showing the high fidelity findings with the intraoperative ones. (cp, capillary perforators; sdV, subdermal venule) Notice the scale on the right side.
perforator in order to identify tiny perforators and not true capillaries, which are obviously different vascular entities. After their first description by Koshima, only a few papers emerged on the topic, and as of now, there is still no accepted nomenclature for these flaps.

Our clinical experience on more than 20 cases with skin cancer defect of any area of the face, body and extremities all successfully reconstructed using local capillary perforator flaps has lead us to further investigate this novel perforator flaps with dedicated imaging which may allow further precision in flap design and predict the vascular tree.3

In this paper, we report our experience with 2 cases of local capillary perforator-based island flaps and 3 cases of superthin free SCIP flap harvest based on preoperative planning with ultra-high frequency ultrasound (UHF-US) (VEVO MD, Sonosite Fujifilm) using 48 and 70 MHz probes in B-mode and color-doppler mode (see figure 1).

We were able to precisely visualize the capillary perforators piercing the superficial fascia and to follow their course in the hypodermis layer up to and within the dermis layer, thus allowing to precisely mark the superficial fascia perforator location and to precisely trace vascular axiality to optimize flap design orientation. These information goes over the ability of angio multidetector computed tomography scan, frequently used in preoperative planning of traditional perforator flaps.

Intraoperatively, we did confirm all preoperative findings and were able to successfully perform the planned reconstruction. No flap failure was experienced.

To the best of our knowledge, this is the first report on the use of ultra-high frequency ultrasound in the planning of perforator flap surgery and in visualizing capillary perforators.

Our promising preliminary evidence with UHF-US in capillary perforator detection may allow to further expand reconstructive freedom by extending the ability to elevate free capillary perforator flap in other areas of the body.

Conflict of interest

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GV and AH contributed equally to this work.

Disclosure

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Visualization of lymphatic ducts with preoperative ICG lymphography prevents donor-site lymphedema following PAP flap

Dear Sir,

Following the introduction of the profunda artery perforator (PAP) flap for breast reconstruction in 2012, the procedure has gained popularity world-wide.1,2 Though the size of the flap that can be harvested is usually not as much as the deep inferior epigastric perforator (DIEP) flap, the anatomy of the perforator is reliable and the pedicle vessels have adequate caliber for anastomosis to the internal mammary vessels. In addition, the scar of the donor site is relatively
inconspicuous. It has since become a novel alternative to the DIEP flap for breast reconstruction.

One of the complications that can occur following the PAP flap is donor-site lymphedema. The risk of lymphedema with this flap is low, however once lymphedema occurs the lives of patients are totally changed due to the necessity for additional surgeries and daily compression therapies. For this reason, surgeons require the utmost care not to damage the lymph collecting vessels running along the medial thigh.

The preoperative indocyanine green (ICG) lymphography inspection is a novel technique to gain knowledge of the region to "keep out" of in dissecting the anterior edge of the PAP flap. To begin with, 0.2 ml (Diagnogreen 2.5 mg/mL) is subcutaneously injected into the donor side lower extremity at the first web space of the foot and the lateral border of the Achilles tendon. A few minutes after injection, fluorescent images of the lymph collecting vessels are obtained using an infrared camera system (PDE; Hamamatsu Photonics). This is an objective, rapid and effective method of identifying the lymph collecting vessels. With this technique, it is easy to avoid the important risk of donor-site lymphedema (Figure 1).

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References


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Major trauma workload and training among UK plastic surgeons: A survey of BAPRAS members

Dear Sir,

Trauma resulting from road traffic collisions, falls, burns, violence or acts of war kill more than five million people globally per annum. In the United Kingdom (UK), the advent of the hub-and-spoke model for trauma care has centralised the approach to dealing with these severely injured patients. However, clinical overview of the patient’s journey from injury to rehabilitation often remains
fragmented. The co-ordination of multi-disciplinary care into a streamlined pathway continues to be subject to wide regional variation. Recent evidence from military trauma suggests that the introduction of spearhead leadership gives greater oversight to the patient journey, including facilitating the onward transportation to rehabilitation facilities.  

Plastic surgeons perform both elective and emergency work, and play a substantial role in the management of major trauma patients. There is evidence from both the military and civilian setting in the United Kingdom (UK) documenting the breadth and volume of plastic surgery input into major trauma care, including care coordination. A recent UK multi-centre prospective study found 14% of major trauma patients undergoing operative intervention required plastic surgical operative involvement. Plastic surgeons’ holistic approach to reconstruction and rehabilitation makes such specialists appropriately placed to lead on the development of a Trauma Reconstruction subspecialty. A well-documented example of the improved outcomes afforded by coordinated care from resuscitation to rehabilitation is that of open lower limb fractures, for which a combined orthoplastic approach with early soft tissue reconstruction in a MTC setting is the current UK gold standard of care as outlined in the February 2016 national (NICE) guidance. This example illustrates the benefit of focusing clinicians and allied health care professionals on the broader patient journey beyond the immediate management of injury. Despite this, involvement in the management of major trauma is not a necessary component of UK plastic surgical training. There are currently limited formal training opportunities for plastic surgery trainees to gain competencies required to manage complex polytrauma patients, and existing pathways are in their infancy.

The aim of this survey was to canvas the opinion of the consultant body of plastic surgeons in the UK to gain an insight into the need for such training, and how it could or should be delivered to best equip trainees to manage these complex patients as consultants.

An online survey was sent to all consultant members (n=505) of the British Association for Plastic, Reconstructive and Aesthetic Surgeons (BAPRAS).

One hundred and two consultant plastic surgeons responded to the survey (response rate 20%). Ninety percent of respondents reported to perform on-call work, and more than half worked in or supported a MTC (n=66, 63%), although only 31% (n=32) had undertaken formal major trauma training.

Eighty-two percent (n=84) of respondents strongly agreed that plastic surgeons should play a major role in major trauma, and 79% (n=83) believed that Major Trauma should be a recognised subspeciality interest for plastic surgeons. The majority agreed that all plastic surgery trainees should be trained in major trauma (n=65%, 63%), but respondents were divided on how to organise and deliver this training. Many felt that Major Trauma fellowships should be set up for trainees interested in the field, but there was no consensus on whether such a fellowship should take place before or after the Certificate of Completion of Training.

Respondents largely agreed that the Major Trauma Network has created opportunities for plastic surgery to expand its workforce, areas of clinical practice and research.

The results of this survey suggest that most plastic surgeons (90%) in the UK are involved in emergency work, and that there is a need and a wish to develop formal major trauma training. This will equip the next generation of plastic surgery consultants to realise the opportunities for expansion afforded to the specialty by the creation of the Major Trauma Network. This data supports recent findings from a survey of trainee plastic surgeons, which demonstrated an intent to take on a trauma reconstruction role within their future consultant job plan and a need for an increase in trauma specific training.

A Training Interface Group Fellowship in Major Trauma Management is currently in its infancy in the UK and will be open to applications from trainees in general surgery, orthopaedic surgery and plastic surgery. The results of this survey suggest the development of the fellowship should continue to be supported and its progress monitored closely for success.

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References

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