Relationship between buckling of acupuncture needles and the handle type

Claire Shuiqing Zhang,1 Muthu Pannirselvan,2 Charlie Changli Xue,1 Yi Min Xie2

ABSTRACT

Background Most popular single-use acupuncture needles consist of a stainless steel shaft with a handle made of copper coil or plastic stick.

Objectives To determine the strengths and weaknesses of these two handle types for needle buckling.

Methods The buckling load for acupuncture needles with these two different handle types was determined using a digital scale, and the stiffness of stainless steel wires used in different types of acupuncture needles was measured using a Dynamic Mechanical Analysis machine.

Results This study showed that an acupuncture needle with a copper coil handle was far more susceptible to buckling than a needle with a plastic stick handle. The average buckling force of acupuncture needles with plastic stick handles was 46.7% higher than that with copper coil handles for needles of 0.25 mm×30 mm, and 30.8% higher for needles of 0.25 mm×60 mm. Replacing a copper coil handle with a plastic stick handle could save about 100 tonnes of copper wires and 20 million metres of medical grade stainless steel wire a year worldwide.

Conclusions The results from this study suggest that the common practice of using coiled copper for handles on acupuncture needles should be re-evaluated. Replacing a copper coil handle with a plastic stick handle would significantly reduce needle buckling and improve patient comfort and safety. This would also reduce the consumption of copper and medical grade stainless steel wire considerably.

INTRODUCTION

Acupuncture involves inserting needles into certain areas of the body to produce therapeutic effects. It has been widely used in complementary medicine.1–4 Various materials have been used to manufacture acupuncture needles, particularly metals, including gold, silver, bronze and stainless steel.1,2,5 Contemporary acupuncture-related treatments can be applied through a range of stimulation devices, including needles, acupressure seeds/pellets and electrical or laser stimulation; of these, fine needles are the most commonly used instrument.6,7 Single-use, disposable acupuncture needles were introduced in the late 1970s following public concern about inadequate infection control of reusable acupuncture needles.5 Since then, single-use disposable needles have been gradually adopted worldwide. A study on the quality of commonly used acupuncture needles was conducted recently.8

An acupuncture needle typically consists of five named parts as shown in figure 1. The shaft (also called body) of a needle is of different lengths (ranging from 13 to 125 mm, with 30–50 mm being the most commonly used length) and diameters (ranging from 0.10 to 0.45 mm, with 0.22–0.35 mm being the most commonly used diameter).9

In clinical practice, it is often difficult for the acupuncturist to insert long needles (≥40 mm) by holding only the needle handle without touching the needle shaft, because a long, fine needle can easily bend (also known as buckle) during insertion. Although one may use a plastic guide tube or a needle inserter to help the initial needle insertion, this does not solve the problem of possible needle buckling when advancing the needle further into tissue. To deal with this technical difficulty, two methods can be used. The first, is to use a needle of larger diameter, but this might cause more pain and discomfort to the patient owing to tissue damage. Hence, this is not the preferred option. The second option, which is more commonly used, is for the acupuncturist to hold the needle shaft to
assist the needle insertion. However, this approach compromises the infection control requirements of acupuncture practice. The World Health Organization and other regulatory bodies require that the acupuncturist’s fingers must not touch the needle shaft during the needling process, including positioning, insertion and manipulation, as the fingers should be considered contaminated.\(^{10-15}\) Therefore, reducing needle buckling should improve infection control of acupuncture and enhance patient comfort and safety.

This study aimed at determining the strengths and weaknesses of different handle designs for needle buckling. Here we compare the two most common designs of acupuncture needle handles—one with copper coil and the other with plastic stick.

**MATERIALS AND METHODS**

**Acupuncture needles being investigated**

Prepacked, sterilised, single-use acupuncture needles of two widely used commercial brands, one made in China with copper coil handles (hereafter called C needles) and another made in Japan with plastic stick handles (hereafter called P needles), were investigated. Owing to commercial sensitivity, the identities of the manufacturers are not disclosed in this article. The shafts of both types of needle were made of medical grade stainless steel. Needles tested for buckling load in this study were of the same nominal shaft diameter of 0.25 mm, with two different shaft lengths of 30 and 60 mm (excluding the length of the handle).

**Needle buckling tests**

Under a compressive longitudinal force, a thin needle behaves in a similar way to a slender column. When the force reaches a critical level, the needle starts to bend. This phenomenon is known as buckling, and the force at which the buckling occurs is called the buckling load. To measure the buckling load of acupuncture needles, we used a digital scale (Adventurer Pro AV812C, Ohaus Corporation, Pine Brook, New Jersey, USA) with a maximum capacity of 810 g (7.9 N) and a resolution of 0.01 g (0.1 mN). The digital scale and the setup for the buckling test are shown in figure 2A. A piece of paper was placed on top of the solid metal surface of a digital scale to prevent the needle tip from slipping.

All the buckling tests were performed by a qualified acupuncturist with 20 years’ clinical experience of acupuncture. At the start of each test, the acupuncturist held the needle perpendicularly to the surface, as shown in figure 2B, and then gradually increased the downward force. When the force was small, the needle remained straight. However, as the force was further increased to reach the critical level, the needle began to bend, as shown in figure 2C,D. At this moment, the digital scale reading was recorded as the buckling load of the needle.

**Needle shaft stiffness measurement**

To prove that the difference in buckling loads was due to the difference in the handle rather than the shaft, we measured the stiffness of steel wires from both types of needles using a Dynamic Mechanical Analysis (DMA) machine (DMA Q800, TA Instruments, New Castle, Delaware, USA), as shown in figure 3A,C. The needle shaft could be loaded in three possible ways as illustrated in figure 3B. In this study, the single cantilever mode was adopted. The needle was clamped at the root and the force was applied at the tip perpendicular to the needle shaft. As all needle shafts tested in this work were of the same diameter and length, a simple measure of the stiffness was defined as the value of the applied force divided by the deflection at the needle tip. The force was gradually increased from 0.01 to 0.1 N at a very slow rate of 0.02 N/min. Thus, the force could be considered as static.

**RESULTS**

As shown in figure 4A–D, the main difference between the two types of needles was in the handle design. The handle of the P needle was made of a plastic stick, while the handle of the C needle comprised a copper coil tightly wound around the upper part of the stainless steel wires.

For the buckling tests, needles with two different types of handles, of the size of 0.25 mm×30 mm and 0.25 mm×60 mm were indiscriminately chosen from prepacked boxes. The buckling tests were conducted on 10 needles of each size and each type. Table 1 presents buckling loads of all needles from the buckling tests. For the 0.25 mm×30 mm needles, the buckling load of the needles with plastic stick handles was found to be 46.7% greater than that of the needles with copper coil handles (353.4±32.1 vs 241.5±23.9 mN, \(p<0.001\)); while for the 0.25 mm×60 mm needles, the buckling load of the needles with plastic stick handles was found to be 30.8% greater than that of the needles with copper coil handles (127.4±8.3 vs 97.4±4.8 mN, \(p<0.001\)).

For the needle shaft stiffness measurement, three 0.25 mm×30 mm needles with copper coil handles (C\(_{10-11}\), C\(_{10-12}\), C\(_{30-13}\)) and three with plastic stick handles (P\(_{10-11}\), P\(_{30-12}\), P\(_{30-13}\)) were indiscriminately chosen from prepacked boxes. Using the DMA machine, the shaft stiffness of the six needles was recorded at various static forces. The average shaft stiffness of the C needles was 87.50, 91.88 and 96.27 N/m when the static force was 0.06, 0.08 and 0.1 N.
0.10 N, respectively; while the average shaft stiffness of the P needles was 85.53, 90.49 and 95.25 N/m at the same forces. Thus, at <2.3%, the shaft stiffness is not appreciably different between the two types of needle. Detailed results of the shaft stiffness measurements are given in online supplementary table S1.

DISCUSSION

Buckling of acupuncture needles with different handle types

The results show that P needles displayed significantly greater buckling loads than C needles, although the stiffness of the two types of needles is similar. Indeed, the steel wire of the C needles was slightly stiffer than...
that of the P needles. Therefore, the large difference in buckling loads of the two types of needle cannot be attributed to differences in the steel wires. The main contributing factor to the difference in buckling loads is that the copper coil handle is quite flexible, whereas the plastic stick handle is far more rigid. This results in the lower part of the copper coil handle being bent and the plastic stick handle remaining straight when buckling starts to occur, as shown in figure 2C,D. This means that the buckling-related effective length of the C needles is considerably longer than that of the P needles, leading to the lower buckling load of C needles. As a result of the increase of needle shaft length, the buckling-related effective length increased and therefore the buckling load decreased. Also, the ratio of buckling-related effective lengths of needles with different types of handle decreased, therefore the percentage of buckling load difference became lower for longer needles. However, the 30.8% difference of buckling load for needles of 0.25 mm×60 mm with different types of handle is still statistically and practically significant.

### Material consumption of acupuncture needles with different handle types

It was estimated recently that two billion acupuncture needles are used each year worldwide. Most of these needles are manufactured in China, and the vast majority have copper coil handles. To determine the amount of copper wire used in making acupuncture needles, the copper coils of a number of C needles were unwound and pulled out, as shown in figure 4E. The copper coil from each C needle weighed about 0.1 g. At a conservative estimate, half of all acupuncture needles used

### Table 1 Buckling loads of acupuncture needles with two different types of handles

<table>
<thead>
<tr>
<th>Needle size: 0.25 mm×30 mm</th>
<th>Needles with copper coil handles</th>
<th>Needles with plastic stick handles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C30-1</td>
<td>C30-2</td>
</tr>
<tr>
<td>Buckling loads (mN)</td>
<td>232.0</td>
<td>262.4</td>
</tr>
<tr>
<td></td>
<td>P30-1</td>
<td>P30-2</td>
</tr>
<tr>
<td></td>
<td>302.0</td>
<td>376.6</td>
</tr>
<tr>
<td>Needle size: 0.25 mm×60 mm</td>
<td>Needles with copper coil handles</td>
<td>Needles with plastic stick handles</td>
</tr>
<tr>
<td></td>
<td>C60-1</td>
<td>C60-2</td>
</tr>
<tr>
<td>Buckling loads (mN)</td>
<td>94.4</td>
<td>89.6</td>
</tr>
<tr>
<td></td>
<td>P60-1</td>
<td>P60-2</td>
</tr>
<tr>
<td></td>
<td>113.7</td>
<td>125.2</td>
</tr>
</tbody>
</table>

worldwide have copper coil handles, which would consume 100 tonnes of copper coil a year.

Figure 4B,D shows that each C needle uses much longer steel wire than a P needle. In this study, the length of steel wire in a C_{30} needle was about 54.5 mm, compared with about 34.0 mm in a P_{30} needle. Such a substantial difference has significant economic and environmental implications because replacing the copper coil handle with a plastic stick handle would save 38% of steel wire for each needle. This is equivalent to a substantial saving of about 20 million metres of medical grade stainless steel wire a year.

The copper and steel materials used in acupuncture needles are rarely recycled because used needles must be discarded immediately into a sharps box and disposed of as clinical waste.\textsuperscript{15}

One argument against the use of plastic stick handles in acupuncture needles is that they are less easy to use for electroacupuncture. However, a new design of acupuncture needle has been developed recently which uses conductive plastic material for the handle,\textsuperscript{17} thus overcoming the drawback of the conventional plastic stick handle. This new type of needle can be effectively used for electroacupuncture. Another problem of plastic handles is that they are unsuitable for use with moxibustion.

CONCLUSIONS
These findings suggest that the practice of using copper coil handles in disposable acupuncture needles should be re-evaluated. We compared the two mostly commonly used handle designs—copper coil and plastic stick. Based on the results, the following conclusions can be drawn.

1. An acupuncture needle with a copper coil handle is far more susceptible to buckling than a needle with a plastic stick handle. This is because the copper coil handle is quite flexible, whereas the plastic stick handle is far more rigid. It was found that the average buckling force of acupuncture needles with plastic stick handles was 46.7\% higher than that of 0.25 mm×30 mm needles with copper coil handles, and 30.8\% higher for 0.25 mm×60 mm needles with copper coil handles, even though the stiffness of the stainless steel wires used in the two types of needles was almost the same. Replacing the copper coil handle with the plastic stick handle could enhance the safety and comfort of acupuncture treatment.

2. Around 100 tonnes of copper wires are used annually for making acupuncture needles. Furthermore, the length of stainless steel wire used in an acupuncture needle with a copper coil handle is significantly longer than that in needles with a plastic stick handle. For acupuncture needles of the same gauge, replacing the copper coil handle with a plastic stick handle could save 38\% of steel wire for each needle, equating to a substantial saving of about 20 million metres of medical grade stainless steel wire a year.

3. The evidence for the discontinuation of the widespread practice of using copper coil handles in disposable acupuncture needles is overwhelming. Although the plastic stick handle is gaining in popularity, further innovations in developing alternative materials and new designs for acupuncture needles are worth exploring.

Summary points

- We compared acupuncture needles with copper coil handles and plastic stick handles.
- Needles with copper coil handles were significantly more susceptible to buckling and used more steel wire than needles with plastic stick handles.
- The practice of using copper coil handles for acupuncture needles should be re-evaluated.

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