

# Enhancing Medical Needle Placement with Auditory Display

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## Abstract

Radiofrequency ablation is a minimally invasive procedure used to treat a tumor by applying local radiofrequency energy using a needle that is inserted into the patient through the skin. Current methods for guiding needle placement require the radiologist to remove the view from the patient and instead use a computer screen for guidance. We present two auditory display methods to guide needle placement that allow visual attention to remain on the patient. Initial results indicate that the needle placement task can be accomplished using almost solely auditory support, increasing user attention on the patient and reducing head and neck movements.

## 1 Deficiencies of Visual-Only Guided Medicine

In radiofrequency ablation (RFA) for tumors, surgical tasks consist of placing the tip of an ablation needle onto the surface of the patient, aligning the needle so that its insertion angle matches a preplanned angle, and then inserting this needle so that the tip reaches the target lesion. Once the tip has reached the target, radiofrequency energy is applied until the lesion is completely ablated, meaning that the tumor has been effectively destroyed. To ease the transfer of the pre-interventional treatment plan to the interventional situation and to ensure optimal tumor coverage, navigation systems and screens have been proposed to show the position of the needle in reference to the patient's body either on a computer screen or, recently, projected onto the patient body (Mundeleer et al. 2008, Gavaghan et al. 2011). However, viewing a screen located elsewhere in the operating room requires that the physicians remove visual attention from the patient in order to view the guidance cues on the navigation system screen in an operating environment already overloaded with visual cues (Vickers & Imam 1999), and direct projections onto the patient are obscured or distorted by hand and instrument placement. We hypothesize that a thoughtful, focused auditory display to replace or augment the existing visual guidance methods will benefit the physician by allowing physicians to remain focused on the patient. Although auditory feedback is common in anesthesia, auditory display for navigated medicine is a nascent field with only Woerdeman et al. (2009) and Hansen et al. (2012) providing basic evaluations of the use of auditory displays in surgical applications.

## 2 Image-Guided Ablation Needle Placement

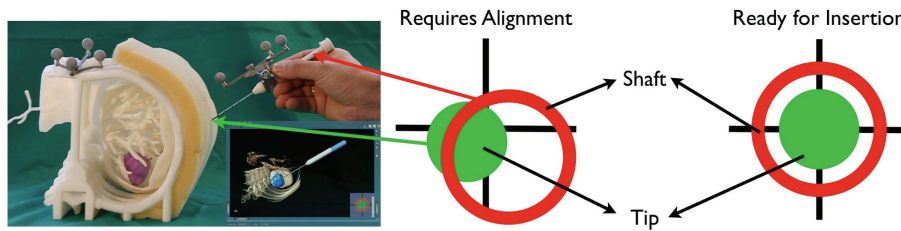


Figure 1: Left: testing model with needle. Right: visual alignment of tip and shaft on navigation system screen

The current visual guidance method for RFA (Gavaghan et al. 2011) uses a crosshair and two circles to denote tip placement and the angle of the shaft. In the first step, the tip of the ablation needle is navigated to a predefined point on the skin of the patient. This can be approximated as a plane at the local point of insertion. Currently, a green circle is shown, which helps align the tip of the needle. When the green circle is directly centered on the crosshair graphic, the tip is in the correct position. In the second step, the shaft of the ablation needle is aligned towards the correct insertion angle while maintaining the tip at the correct position. To visualize this step a second, hollow circle (red, above) displays the error of the actual shaft angle to the planned shaft angle. When the red circle is centered on the crosshairs, the angle is correct for insertion. Insertion status is shown as a vertical progress bar on the screen, depicting the absolute distance from tip to goal in the tumor.

## 3 Auditory Display Method

The distance of the tip or shaft (*'tracked elements'*) to the planned goal is received in two dimensions from the navigation system. For both tip placement and shaft alignment, the same auditory method may be employed, repeated for each step. In the first auditory method (Fig. 2, left), changes in absolute distance to the y-axis are linearly mapped to speed between pulses, slow at the left and right edges, progressing faster towards the center. Changes in absolute distance to the x-axis are mapped to alternating pitches, which converge towards the center, much like tuning a guitar. In the second auditory method (Fig. 2, right), changes in absolute x distance are linearly mapped to both speed between pulses and pitch. Once the tracked element is within 10% of the y-axis, a second pulsing tone replaces the first, with similar speed between pulses but a higher pitch mapping. Thus, the user approaches from either side and when near the y-axis proceeds to approach the center. Insertion depth is transmitted via two alternating tones with an interval of separation of one octave before insertion and rising to equal pitch when reaching goal depth.

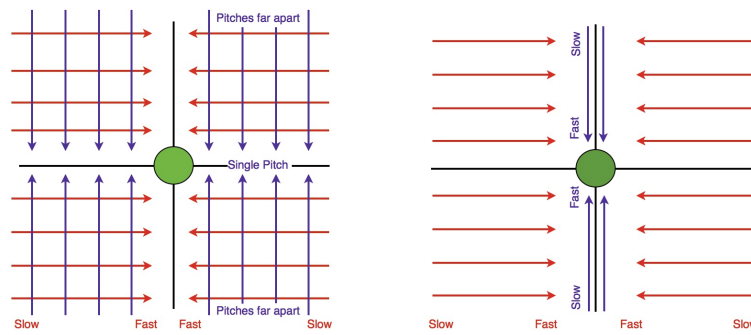


Figure 2: Auditory methods: in the first, note pitches and pulse speed vary, and in the second, slower and faster pulses are mapped to x- and y-axes

## 4 Evaluation

Two females and six males volunteered to participate in the study. All participants claimed not being particularly musical, three out of eight had a basic understanding of playing and tuning a guitar, one participant had basic knowledge of digital audio synthesis. All were scientific personnel with basic anatomical knowledge. No participant had experience with radiofrequency ablation or the auditory display system. The participants were introduced to the different methods and went through a short training session for each. Afterwards each participant completed a set of tasks: positioning the tip, adjusting the angle of the handle, and inserting the needle until the target had been reached. Participants were asked to think aloud and talk about what they were doing, thinking, and feeling (according to Lewis 1982).

Both audio and visual method were described as being easy to learn and use. All participants estimated the audio methods to be at least as good and precise as the visual method. The audio methods were preferred by seven (all but one) participants, some of whom commented, “you can see what you’re doing” on the model and do not have to look at the screen, and “... with sound it’s much easier” because “... the human ear is much better than the human eye.” Participants also felt more confident in finding the right spot for the tip. Also the participants enjoyed the experience of navigating using audio and felt it being “like a video game”. When reaching the target area, the system gave the user feedback in form of a chime, to which all participants reacted positively and even showed signs of real joy.

Even though the visual method was criticized due to the fact that the user had to look at the screen and back at the model, and thus being described as “shaky”, some participants felt more confident using this method as they could still correct the position of the tip and the angle of the handle while pushing the needle towards the target. Using the audio method, they could not monitor their tip position, handle angle, and needle depths simultaneously as they could with the visual method. None of the participants was annoyed by the sounds. All participants understood that sound speed and pitch reflected the urgency of the current position. However, participants suggested choosing more instrumental timbres rather than basic synthesized tones.

## 5 Conclusion

A comparison of the two audio methods and the current visual guidance method in terms of learnability, user acceptance and ease of use has been conducted. First results show that the audio methods allow almost blind placement of the needle and are easy to use and understand, but still need some refinement. Observing the physical model while performing a task and hearing the distance to target improved the confidence of all participants. Nevertheless, visual feedback gave two participants a greater feeling of control. Following this preliminary study and the positive feedback and results, our aim is to refine the audio method and evaluate precision and speed in comparison to the visual guidance method. Additionally, users' confidence in finding the accurate point and angle to reach the target must be investigated. More exhaustive studies will be conducted with physicians to understand the applicability of audio display in a surgical environment.

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