The Origin of the N-Localizer for Stereotactic Neurosurgery

Russell A. Brown 1, James A. Nelson 2

1. Principal Engineer, A9.com 2. University of Washington School of Medicine

Corresponding author: Russell A. Brown, russ.brown@yahoo.com
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Abstract

More than three decades after the invention of the N-localizer, its origin remains misunderstood. Some are unaware that a third-year medical student invented this technology. This historical vignette provides an accurate chronicle of the origin and early history of the N-localizer.

Categories: Medical Physics, Radiation Oncology, Neurosurgery
Keywords: stereotactic radiosurgery, image guidance, stereotactic neurosurgery, computed tomography, magnetic resonance imaging, n-localizer

Introduction And Background

Russell A. Brown invented the N-localizer more than thirty years ago, when he was a third-year medical student and during a research elective under the supervision of James A. Nelson at the University of Utah [1]. Since that time, the N-localizer has achieved widespread use in image-guided stereotactic neurosurgery and radiosurgery. The N-localizer produces two circles and one ellipse in sectional images that are obtained via computed tomography or magnetic resonance imaging (Figure 1). The relative spacing between the ellipse and the two circles precisely determines the location of the image section relative to the N-localizer [1-2]. The simplicity and accuracy of the N-localizer render it an important tool for modern neurosurgery and radiosurgery. Ironically, however, the accuracy of the N-localizer does not appear to be mirrored by a consistently accurate understanding of its origin.

Lunsford, et al. have claimed [3] that "During the subsequent years of training, the senior author had an opportunity to work with an innovative neuroradiologist, Arthur Rosenbaum, M.D., and an engineer, John Perry, Ph.D., who then headed the imaging division of Pfizer Medical Instruments. Together, we developed an image-guided stereotactic system using the now well-known N-localizer technology. This elegant solution was proposed by Perry, et al. [4] and Rosenbaum, et al. [5] independently and virtually simultaneously as publications from Brown [2] and Roberts and Brown [6] of Utah."

In the preceding statement, the intended antecedent of "elegant solution" could be either "image-guided stereotactic system" or "N-localizer technology". Perry, et al. did propose an image-guided stereotactic system [4] several months after Brown, et al. proposed the Brown-Roberts-Wells (BRW) image-guided stereotactic system [7]. However, the historical record shows that none of the above-mentioned individuals, with the exception of Brown, invented the N-localizer. Instead, Perry adopted the N-localizer after Brown disclosed it to him. The documents that corroborate these facts have remained preserved in the archives of the U.S. Patent and Trademark Office for the past 26 years. The following discussion, which is based on...
these archives, recounts Perry’s research related to image-guided stereotactic surgery and reveals the events that led to his adoption of the N-localizer.

**FIGURE 1: N-localizer and its interaction with the computed tomography (CT) scan section**

(A) Side view of the N-localizer. The CT scan section intersects two vertical rods and one diagonal rod. (B) CT scan image. The intersection of the CT scan section with the N-localizer produces two circles and one ellipse. The relative spacing between the ellipse and the two circles varies according to the height at which the CT scan section intersects the diagonal rod. Measuring this spacing permits calculation of the location of the CT scan section relative to the N-localizer.
Review

Several researchers had described a method for estimating the position of the computed tomography (CT) scan section [8-9]. This method used a plate into which were milled vertical slots of different lengths, such that the tops of the slots lay along a diagonal line (Figure 2). The slotted plate produced a variable number of notches in the CT scan image. The number of notches depended on the height at which the CT scan section intersected the plate. Counting the number of notches that were visible in the CT scan image allowed estimation of the location of the CT scan section relative to the slotted plate.

Lunsford discovered that the attachment of two slotted plates to a stereotactic frame permitted determination of the height of the CT scan section relative to the base of the frame [10]. Perry, et al. extended this concept via the attachment of a third slotted plate to the stereotactic frame; the third plate allowed calculation of the orientation of an arbitrarily oriented CT scan section relative to the base of the frame [11]. In principle, this slotted-plate technique that utilized three slotted plates could create the same spatial information that was created by three N-localizers [1-2].

In practice, however, the slotted-plate technique was susceptible to error as a result of the discrete or quantized nature of the slots. Perry observed that it was necessary to manually count carefully the numerous notches that were visible in the CT scan image because any miscount would give rise to errors in the subsequent calculation of the orientation of the CT scan section [11]. Moreover, the partial volume effect [12-13] that derives from the finite thickness of the CT scan section impeded accurate counting of the notches because any slot that passed into but not entirely through the CT scan section could produce an only faintly visible notch. For these reasons, the slotted-plate technique was vulnerable to human error and hence was unsuitable for clinical use. The N-localizer avoids these quantization problems and the attendant possibility of computational errors by virtue of the continuous nature of the N-localizer’s rods.
FIGURE 2: Slotted plate and its interaction with the computed tomography (CT) scan section

(A) Side view of the slotted plate. The CT scan section intersects the plate into which are milled vertical slots. The tops of the slots lie along a diagonal line. (B) CT scan image. The intersection of the CT scan section with the slotted plate produces a variable number of notches. The number of notches depends on the height at which the CT scan section intersects the plate. Counting the number of notches permits estimation of the location of the CT scan section relative to the slotted plate.

Perry’s earliest report of the slotted-plate technique, and indeed the earliest record of his involvement with image-guided stereotactic surgery, was in his letter dated January 15, 1979 addressed to his collaborators, Dade Lunsford, Arthur Rosenbaum, and David Zorub of the University of Pittsburgh [11]. Perry’s letter described the attachment of three slotted plates to a
stereotactic frame and provided instructions for using computer software in conjunction with these slotted plates to calculate the spatial orientation of the CT scan section relative to the frame. Well before that date, Brown had already invented the N-localizer [14], built his prototype stereotactic frame [15], and presented his results to the Western Neurological Society and the American Academy of Neurological Surgery [16]. Moreover, on January 29, 1979, Brown submitted for publication the second [2] of his two journal articles that introduced the N-localizer [2, 16].

On January 25, 1979, Brown spoke by phone with one of Perry’s coworkers at Pfizer Medical Systems and learned that Perry’s research involved image-guided stereotactic surgery [17]. The following day, another of Perry’s coworkers at Pfizer Medical Systems sent to a patent attorney a letter that described the slotted-plate technique and that provided several photographs of a stereotactic frame to which three slotted plates were attached [18].

A few days thereafter, Brown spoke by phone with Perry and disclosed the N-localizer to him. Prior to this discussion with Brown, Perry had been unaware of the concept of the N-localizer [19]. Perry may have apprised Rosenbaum of some aspects of this discussion with Brown. Nelson affirms that, during a conversation with Rosenbaum concerning the N-localizer, Rosenbaum revealed his awareness of Brown’s previous discussion with Perry [19].

Several months following his discussion with Perry, Brown was surprised to witness a talk wherein Perry presented the N-localizer [19]. When Perry, et al. subsequently proposed an image-guided stereotactic system that comprised N-localizers instead of slotted plates [4], they cited one [16] of Brown’s two journal articles that had introduced the N-localizer more than one year previously [2, 16]. Several months before Perry, et al. proposed their image-guided stereotactic system, Brown, et al. had already proposed the BRW image-guided stereotactic system [7].

Perry’s earliest description of the N-localizer was cursory and limited to only two sentences in his application to the U.S. Patent and Trademark Office dated April 13, 1979; this same patent application devoted detailed explanations and five drawings to a thorough description of the slotted-plate technique [20]. Upon challenge by Brown, Perry failed to provide any evidence whatsoever of having invented the N-localizer. Consequently, Perry conceded “priority of invention” to Brown [21], and the Patent Office awarded patent protection for the N-localizer to Brown [22]. The documents [11, 14-18, 21] that the Patent Office examined prior to awarding patent protection to Brown instead of Perry are a matter of public record. These documents may be obtained from the patent office by requesting a copy of the folder for Interference No. 101267. In order to facilitate access to these documents, we have included copies in the appendices (labeled as “figures”) to this paper.

Conclusions

Brown invented the N-localizer that has become an important neurosurgical tool and has achieved widespread use in image-guided stereotactic neurosurgery and radiosurgery. Lunsford invented the attachment of two slotted plates to a stereotactic frame. Perry, et al. extended this concept via the attachment of a third slotted plate, but the slotted-plate technique never achieved clinical use [23]. Perry abandoned the slotted plate and adopted instead the N-localizer after Brown disclosed it to him. Several months after Brown, et al. proposed the BRW image-guided stereotactic system that comprised N-localizers, Perry, et al. proposed an image-guided stereotactic system that also comprised N-localizers. However, Perry’s inclusion of the N-localizer in an image-guided stereotactic system did not occur independently of Brown’s discovery of the N-localizer. To the contrary, Perry’s inclusion of the N-localizer was derivative; it originated from Brown’s prior research. The historical documents that confirm these facts are a matter of public record and remain accessible at the archives of
the U.S. Patent and Trademark Office.

Appendices
FIGURE 3: Appendix 1: John Perry Letter, pp. 1-3, January 15,
FIGURE 5: Appendix 3: Russell Brown Notebook 1, pp. 80-83,
The square root of the sum of the squares of the three individual errors is taken to be the error for a probe placement. This is possible because these 3 errors are approximately orthogonal to one another. For the 20 probe placements documented on the preceding page, the mean error is 2.03 mm and the standard deviation is 0.47 mm.

I was present for a number of these tests, witnessed some, and found my calculator for calculations of the mean and standard error on 1/20/79.

1/25/79

I have spoken with Brian Heightman (sp?) of Pfizer Medical Inc. about my stereotactic project. He says that John Perry of Pfizer is working on a similar project and has found that the Pfizer reconstruction algorithm is unaffected (or minimally affected) by aluminum. I would, of course, prefer to use aluminum for the frame fabrication because it is more durable than plastic. 1/25/79.
FIGURE 8: Appendix 6: Russell Brown Notebook 3, pp. 99-102,
FIGURE 9: Appendix 7: John Perry Concession of Priority, November 27, 1985

Additional Information
Disclosures
Conflicts of interest: The authors have declared that no conflicts of interest exist.

References