

## HISTORICAL ARTICLE

# The history of spinal needles: getting to the point

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### Summary

The history of the design of spinal needle tips is discussed, from the first needles used by J. Leonard Corning in 1885 to innovative, modern needle designs that continue to appear on the market. The shape of the needle tip started as a cutting bevel and developed into the atraumatic tip and the pencil-point tip in current common use. Innovative designs such as the stylet-tipped needle and the directional needle are described, as well as the needles used for continuous spinal anaesthesia.

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The history of the development of spinal needles, and in particular of the tip of the spinal needle, began with the understanding of the anatomy and physiology of the central nervous system that pertained at the time of the introduction of spinal anaesthesia. This was followed by the development of new equipment and techniques. The publication of the results of small case series led to a gradual acceptance of spinal anaesthesia into medical practice. Many of the developments should be credited to those pioneering individuals who applied the knowledge available to them at the time, and designed the equipment that is the basis of the needles that we use today. Early developments were often based on incomplete or incorrect information and, as understanding improved, the equipment was modified to improve safety and decrease the severity and frequency of the complications of spinal anaesthesia. As with many medical devices, the occurrence of complications increased the understanding of the subject, and the application of this new knowledge moved developments forward to the next stage.

There is often dispute about who should be given credit for the introduction of spinal anaesthesia into everyday practice, and the same holds true for the development of the various spinal needles. Techniques were often developed inadvertently while performing other procedures. People who pioneered a technique but did not publish their findings until after later users achieved publication may not have had developments correctly attributed to them. Some

authors may have made only minor modifications to someone else's technique and then claimed to be the originators of the technique. The history of the spinal needle, and especially of the design of the tip, is one of ideas, failures, complications and modifications, culminating ultimately in the currently accepted design: small gauge, pencil-point needles. A full understanding of the development of needle tip design is difficult to acquire, as although initial ideas were often published, acceptance or rejection for everyday clinical practice is rarely commented on. Furthermore, early publications were often in foreign-language journals and are therefore difficult to obtain and understand, or are only available as citations in later papers.

### The first spinal anaesthetic

In 1764, Cotugno described the presence of a collection of water around the brain and inside the spinal column. In 1825, Magendie was credited with appreciating that this fluid circulated around the brain and the spinal column. By 1841, Zophar Jayne of Illinois had designed a syringe attached to a small, sharp, hollow beak with an opening on the side near the tip. Subsequently, in 1853, Daniel Ferguson developed a syringe and hollow platinum trochar with an oblique opening on one side encased in an outer tubing, also with an oblique opening. By twisting the outer casing, the openings could be lined up to allow injection. Ferguson is credited by some as being the first to use a hollow needle with a sharpened

extremity, allowing skin penetration and attachment to a syringe. Alexander Wood of Edinburgh, on using Ferguson's needle, thought that it might be useful for injecting into deeper layers, and hence Wood is credited with developing the first hollow hypodermic needle in 1853 [1]. Some years later, the assessment and interpretation of this information meant that the stage was set for the first spinal anaesthetic.

The first spinal anaesthetic was administered accidentally by J. Leonard Corning, a neurologist from New York [2]. In 1885, he was experimenting with the action of cocaine on the spinal nerves of a dog when he accidentally breached the dura between two lumbar vertebrae, causing paralysis of the hindquarters, and hence inadvertently performed the first spinal anaesthetic. His next patient was a man with seminal incontinence who had a transient paralysis after the spinal injection. He then applied this technique to various neurological disorders and called the resulting analgesia 'spinal anaesthesia'. Although Corning did not use spinal anaesthesia for surgery, he did appreciate the potential to do so, and is therefore credited with discovering spinal anaesthesia. Corning developed his own spinal needle and introducer, which he described in the *New York Journal of Medicine* (Fig. 1). The needle was made of gold or 'platina'. The cannula was flexible, with a needle stop and a set screw to fix the needle at the correct depth once the subarachnoid space had been entered. The needle tip was based on the hypodermic needle developed by Wood in 1853. It was sharp, with a short cutting bevel. The introducer was short, with a right-angled handle.

Corning was remarkably prescient with regard to the design features required for successful spinal anaesthesia. He stated that 'the bevel of the point was to be short, so that the needle will not require to penetrate the membranes very far, in order to insure the deposit of the solution within them. Uncouth needles, with a long bevel at the point, are of all things to be avoided. Only imperfect results are to be anticipated from such clumsy instruments, as, on the one hand, an overplus of penetration is requisite to insure the entry of the fluid below the membrane; and, on the other, an immoderate outflow of cerebrospinal fluid – and hence of the anaesthetic – is inevitable after the withdrawal of the needle'.

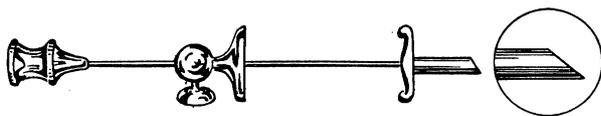


Figure 1 Corning's needle (1900).

### Development of the cutting spinal needle tip

In 1891, Quincke published a paper describing a standardised technique of lumbar puncture for the release of cerebrospinal fluid (CSF) for diseases associated with increased intracranial pressure [3]. He used a needle of which it is difficult to find a description, except that it was a sharp, bevelled, hollow needle.

The next major development in the history of spinal anaesthesia was the work of Augustus Karl Gustav Bier. In 1898, both he and his assistant underwent spinal anaesthesia with cocaine, the assistant first injecting Bier, and then Bier his assistant. The first procedure resulted in Bier experiencing a lancinating pain in his leg while his assistant struggled to connect the syringe to the needle, with a resultant significant leakage of CSF and cocaine solution. The resulting complications were those that are not uncommonly seen to this day: failed block, neural contact with the needle and a postdural puncture headache (PDPH). Bier then performed a successful block on his assistant. After these experiments, Bier took the historic step of using spinal anaesthesia to provide analgesia for surgical procedures. In 1899, he published six case reports of surgery to the lower limbs under spinal anaesthesia with cocaine [4]. The needle used was described as a Quincke needle. Bier's work caused a sensation in the medical world, with widespread acceptance of the technique for surgery, although Bier himself still had reservations. Over time, he developed his own needle (Fig. 2). He felt that the use of introducers and dilators for the insertion of the finer needles previously used was cumbersome, and he designed a larger bore needle that needed no introducer. The Bier spinal needle was 15G or 17G, with a long, cutting bevel and a sharp point.

Soon after the introduction of the Bier needle, the importance of the size of the needle and the shape of its bevel was recognised. Bier's needle was criticised for causing pain on insertion, leaving a large hole in the dura and causing an extradural loss of local anaesthetic solution because the orifice could straddle the dura.

Bainbridge described a needle in 1900 that was attached to a metal syringe [5]. It had a small circular hub, a short, sharp cutting bevel and a stylet with a matching bevel (Fig. 3). It was made of a flexible metal. Barker was the next pioneer in needle design. He described his technique

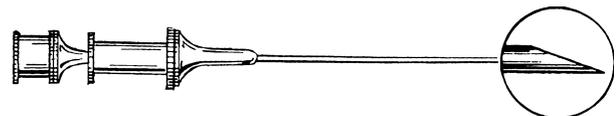


Figure 2 Bier's needle (1899).



Figure 3 Bainbridge needle (1900).

in 1907 [6]. Initially, he used a modified Bier needle but, as he appreciated the problems associated with a long bevel, he designed a hollowed-out point to ‘secure sharpness without lengthening the terminal opening’. He stated that ‘the object of this is that when the puncture is made, the whole of the open end of the needle shall lie within the dura without the point being pushed so far as to wound structures within the sac. It is obvious that if the open end of the needle were only partially thru the dura the spinal fluid might run freely enough thru the needle, but that when the analgesic compound was injected part of it might enter the sac while part of it escaped... in the extradural space. Acting on this conviction, I have since employed the following device for delivering all of the injection compound beyond the actual point of the needle, whether the whole of its terminal opening be actually within the sac or not’. Barker developed a blunt cannula to fit inside the Bier needle that projected 1 mm beyond the needle tip. It was placed after dural puncture by the Bier needle and was connected to a syringe of local anaesthetic solution. The blunt tip was designed to limit damage to intradural structures. At a later, unknown date, Barker designed a needle without the inner cannula, referred to as the Barker needle (Fig. 4). This 18G or 19G needle had a sharp, medium-length bevel and a stylet with a matching bevel. It was a large firm needle that was associated with a significant incidence of PDPH. The early needles were made of ‘steel nickled over’. They quickly discoloured and corroded. Barker advised that needles be made of hard nickel, which was a significant development in the manufacturing of needles.

As early as 1898, Sicard realised that the cause of PDPH was the loss of CSF through dural tears [7]. In 1914, Ravaut advised the use of finer needles to limit the size of the dural tear. In 1914, Babcock [8] described a needle that was closer in design to the original Corning needle but with a finer cannula to limit the incidence of PDPH (Fig. 5). It had a sharp, medium-length bevel with a matching stylet. It was made of iridised platinum or gold and was 20G in diameter. Referred to as the Quincke–

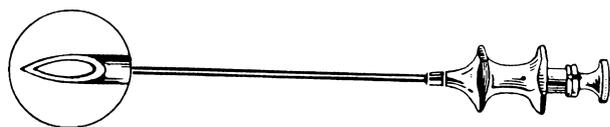


Figure 4 Barker needle (1907).

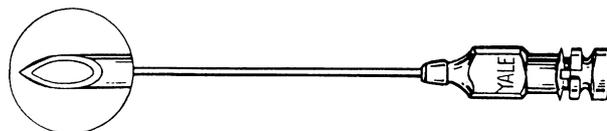


Figure 5 Quincke–Babcock needle (1914).

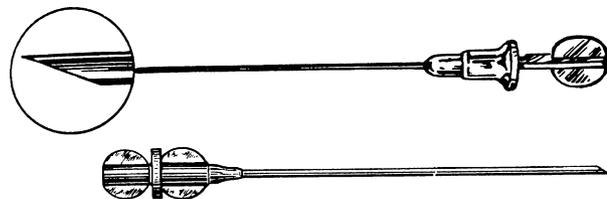


Figure 6 Labat needle (1921).

Babcock needle, it was a very successful needle design and became the standard spinal needle for comparative studies.

Gaston Labat was a well-respected French clinician who moved to America. He was one of the pioneers of the widespread acceptance of spinal anaesthesia in the 1920s in both Europe and the USA [9]. He designed a spinal needle that was made of unbreakable nickel (Fig. 6). It was a medium-gauge cannula with a short, sharp bevel and matching stylet, with the tip ground to match the bevel of the cannula. Labat’s theory was that the shorter bevel acted as a wedge, pushing tissues aside rather than cutting them, and therefore minimising damage to the dura.

In 1922, Hoyt published his theory that the large bore needles in common use were, because of their rigidity, resulting in large holes in the dura and an increased loss of CSF [10]. He proposed the use of a two-needle technique with a larger bore outer needle being used for penetration of the outer tissues and a finer inner needle for penetration of the dura and arachnoid. This was a return to the principles of the finer Corning needle with an introducer, which had been superseded by the larger Bier needle. The outer needle used by Hoyt was a modified Bier needle with a long cutting bevel (Fig. 7). The use of Hoyt needles was associated with a much lower incidence of PDPH than other needles in use at the time.

As with many medical advances, the next development was a technological one. In the 1920s, Firth Bready

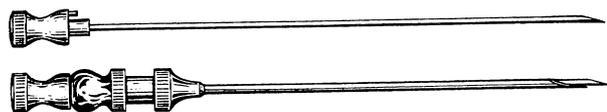


Figure 7 Hoyt needle (1922).

heat-tempered stainless steel was developed in England. This was rust-resistant but not rustproof. Towards the end of World War I, Germany was manufacturing V<sub>2</sub>A steel (a hard steel alloy), and at the conclusion of the war it was exported to America. This steel was rustproof, very resistant to breaking and could be worked to a sharp point that was resistant to deformation. The low carbon steels were replaced by higher carbon, rustproof products that became the mainstay of needle production.

### Atraumatic needle tips

The realisation in the 1920s that the cutting of dural fibres caused increased leakage of CSF, and therefore an increased incidence of PDPH, resulted in the next major development in the history of the tip of the spinal needle. In 1923, Herbert Merton Greene [11] presented his work on laboratory studies of the holes made in the dura by differing needle sizes and tips. He stated that a smaller, less traumatic hole was made in the dura if a cutting tip was replaced by a smooth, round tip. He used an ordinary 23G cutting needle that he sharpened to a rounded tip by removing the cutting edges of the bevel, which resulted in a PDPH rate of only 4%. He continued the clinical use of this atraumatic tipped needle, publishing a further paper in 1926 [12] that described his needle as 'round, tapering and sharp'. He felt that 'post puncture headache is caused by trauma to the spinal dura sufficient to result in excessive leakage of cerebrospinal fluid to the point at which the brain is left without a water cushion'. He showed that the non-cutting tip was able to pass between fibres rather than through them. Of 215 consecutive patients, there were only two patients with headaches.

There is some disagreement in the available literature as to the actual date of the introduction of the needle and the ownership of the needle design. Herbert Morton Greene presented his work in 1923 and 1926, but the design should perhaps be attributed to Barnett A Greene who, in 1950, published on the use of a 26G needle passed through a 21G introducer [13].

The Greene needle was sized between 20G and 26G. The point was a rounded, non-cutting bevel of medium length with a matching, bevelled, fitted stylet (Fig. 8). The rounded bevel causes a smaller dural puncture hole with separation rather than cutting of fibres. It was made

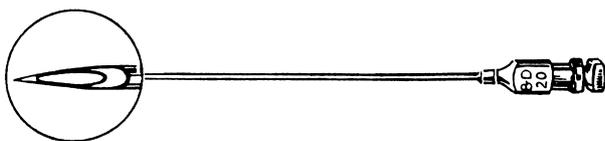


Figure 8 Greene needle (1926 or 1950).

of flexible, rustproof, soft-temper stainless steel with a low incidence of needle fracture. The Greene needle became very popular, especially in obstetrics, due to its low incidence of PDPH, and was the only atraumatic needle in common use until the introduction of the Whitacre needle in 1951. Manufacturing finally stopped in the 1980s.

### Further modifications to the cutting bevel

Further consideration was then given to the shape of the tip and how to minimise dural trauma. The next needle developer was an American surgeon called George Praha Pitkin [14]. Pitkin was a strong proponent of regional anaesthesia, believing it to be far safer than the alternative of a general anaesthetic. He was innovative in his practice. He appreciated that the shape of the needle tip affected the hole left in the dura and the extent to which CSF leaked out of the hole. He devised a 20G or 22G needle made of relatively flexible rustproof steel with a collar to mark the depth of insertion (Fig. 9). The tip of the needle had a short, sharp bevel ground off to a taper of 45°, resulting in a rounded, blunted bevel heel. There was a matching, bevelled stylet. Pitkin's theory was twofold. The first part was that this tip shape would transmit the sensation of dural puncture more accurately and therefore correct intrathecal positioning of the tip of the needle would be better appreciated. Secondly, the needle would cut a 'trap door' in the dura that was closed by the intradural pressure as the needle was withdrawn, thereby limiting loss of CSF. Pitkin advocated the insertion of the cutting edge of the bevel parallel to the longitudinal fibres of the dura. Maxson refuted Pitkin's theory of the 'trap door' in a publication in 1938 [15], in which he stated that all needles created a CSF leak.

### The first stylet-point needle

Although most publications concentrated on the cutting tip of the needle itself, there was one developer who thought a little more laterally and devised an innovative needle shape that has been revisited occasionally over the years, and is still being considered to this day. Sise [16] published an article in July 1928 followed by a second article published in December 1928. The first article

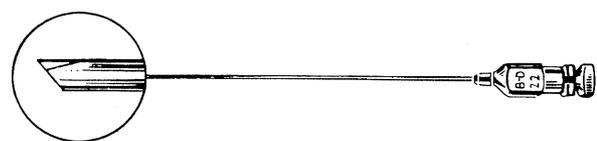


Figure 9 Pitkin needle (1927).

described spinal needles of nickeloid or rustproof steel, of the finest gauge that could be used in practice (20G or 22G). Sise stated that long-bevelled, sharp, pointed needles should not be used, as part of the needle orifice may be inside the dura while the rest is outside. A needle bevel of 45° was considered satisfactory, preferably with a conical point similar to Greene's needle. Sise took Greene's needle a step further, preferring it to be conical all the way round, resulting in the separation of the longitudinal fibres of the dura rather than cutting the fibres, allowing the dura to close again readily. Sise theorised that this design, as well as the finer gauge, resulted in less fluid leakage and fewer PDPHs. The second of Sise's publications [17] described a 22G needle made of rustproof steel. He devised a point which he hoped would inflict minimal trauma while delivering the anaesthetic solution within the dura. His needle was 'of conical point, one which is bevelled equally all the way round and of which the stylet forms the apex'. On removing the stylet, the end of the needle formed a flat opening at right angles to the shaft.

### Directional spinal needles

Many minor modifications to the cutting bevel had been described since the acceptance of spinal anaesthesia into modern anaesthetic practice, but significant problems were still encountered, namely PDPHs and loss of spinal anaesthetic solution into the epidural space. A new design was needed. The next needle tip design evolved gradually, again with the initial publication of a design concept followed by minor modifications as problems were encountered and overcome. The next phase of development was that of the closed needle end with a lateral orifice, which forms the basis of the pencil-point needle in common use today.

Barker was credited with designing the first directional closed-end spinal needle, but a quotation from 1912 indicates that this was not the case [18]... 'I have lately seen one of those little cannulae, purporting to be mine, made with a closed end and a lateral opening short of the point which could only discharge the solution outside of the dura in many cases. It was hopelessly wrong...'. In fact, it was Kirschner from Germany who was the first to publish on the use of a closed-end directional needle in 1932 [19]. He described a directional spinal needle with a solid end bevelled to a 45° point and with a lateral opening on the long side of the bevel proximal to the point. He claimed that the lateral orifice allowed unilateral, cephalad or caudal anaesthesia to be administered. Although supported by some recognised workers in the field, Kirschner's needle failed to gain wide acceptance.

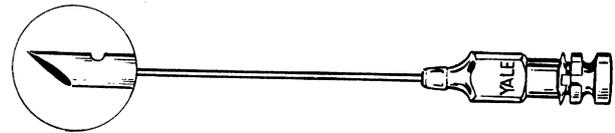


Figure 10 Rovenstine needle (1944).

Rovenstine took up the design idea of the closed-end needle and in 1944 published a paper describing his spinal needle [20]. He initially looked at an alternative design to the open-ended bevel needle to overcome the problem of the effect of the direction of the bevel in determining the extent of anaesthesia. He felt that if the end of the needle were closed, the direction of the orifice could be used to control the spread of anaesthesia. Rovenstine's needle was 19G or 20G (Fig. 10). It had a closed, short-bevelled point with a lateral orifice 2 mm from the distal end of the needle. The fitted stylet had a matching bevel that occluded the orifice when seated. The lateral orifice allowed directional flow and therefore control of the spread of the local anaesthetic agent. This theory has since been disproved, with the direction of the orifice having been found to have little effect on the extent of spread of the local anaesthetic solution [21]. The 2 mm distance of the orifice from the tip of the needle meant that the needle needed to be inserted more deeply into the subarachnoid space than may be ideal.

### Pencil-point needles

Once the suggestion that dural fibres were less likely to be damaged by non-cutting tips had been publicised, it was only a matter of time before the advent of the completely non-cutting needle tip. Kirschner and Rovenstine's needles, which had a lateral orifice, contributed to the next phase of needle tip design. As with many medical discoveries, those credited for the introduction of a new aspect of equipment design were not those who first described it. Hart and Whitacre are commonly associated with the design of the first closed-ended, lateral orifice, pencil-point needle, but a Swedish doctor called Haraldson published a paper in 1951 [22] (several months before Hart and Whitacre) that described a needle he had developed to decrease the incidence of PDPH. The needle was of fine gauge, with a solid non-cutting tapering point and an orifice on the conical surface 2 mm from the actual tip of the needle. He quoted a PDPH rate of 9% for the non-cutting needle (none severe) as opposed to 32% (18% severe) for a cutting needle. The Haraldson needle failed to gain the recognition it deserved, possibly because it was manufactured in only small numbers locally, so it was the writers of the next

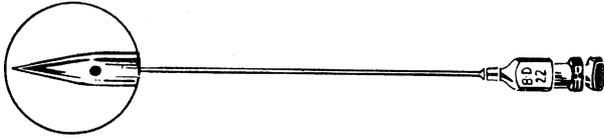


Figure 11 Whitacre needle (1951).

description of this sort of needle who have received the recognition.

Hart and Whitacre published their paper entitled 'Pencil point needle in prevention of post spinal headache' in October 1951 [23]. They acknowledged the work of H. M. Greene in 1923 in advocating minimising trauma to the dural fibres. They approached Becton Dickinson with a needle design 'of a 20 gauge needle with a solid end drawn to a point similar in shape to a finely sharpened pencil. The opening is on the side of the needle, just proximal to the solid tip' (Fig. 11). The original needle was actually a solid conical tip attached to a hollow cannula, with the orifice immediately proximal to the tip. They reasoned that the tip separated the longitudinal fibres of the dura and arachnoid without traumatising them. When the needle is withdrawn, the fibres return to a state of close apposition, thereby minimising CSF leakage. They accepted that they had no direct evidence but reported a PDPH rate of 2% compared to the 5–10% rate seen with other commonly used cutting needles. In addition, they reported a decrease in the severity of the headaches seen after the use of a pencil-point needle. There was a more appreciable 'dural click' with the pencil-point needle.

The original Whitacre needle had its problems, namely, the orifice was very small, making aspiration and injection difficult, and the stylet did not occlude the orifice, which could therefore become blocked with tissue. However, the basic design was a success, and the Whitacre needle is still in common use today with only a few minor modifications to its original design. Even after the widespread acceptance of the pencil-point needle and the acknowledgement that it was an advance in the design of spinal needles, there were still modifications of cutting bevel needles being developed, mainly the introduction of finer gauges. In 1955, Brace [24] produced a needle with a medium length, sharp, cutting bevel (Fig. 12).

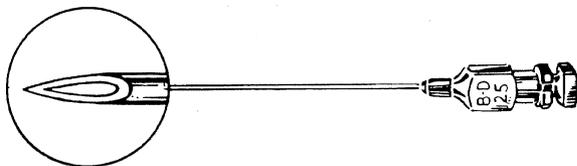


Figure 12 Brace needle (1955).

The 1950s proved a difficult decade for spinal anaesthesia, with the publication of a number of reports of the long-term sequelae of spinal anaesthesia, including persistent neurological damage, headaches and even death. The Woolley and Roe cases [25] in 1947 highlighted the fact that serious harm was possible if an imperfect technique was used. Spinal anaesthesia became much less popular, and this was reflected in the lack of development of the technique over the ensuing years. Even so, there were still many supporters of regional anaesthesia who kept publishing data proving the safety of the technique. Eventually, their persistence paid off, and there was a resurgence in interest and development by the 1980s.

### Continuous spinal anaesthesia needles

While most were striving to improve the design of spinal needles to decrease the incidence of complications, some workers were looking at ways of improving the technique of spinal anaesthesia to make it applicable to more surgical procedures. One of the limitations of spinal anaesthesia was its limited duration: only 1–1.5 h of adequate analgesia could be expected after a single-shot injection. If a technique of continuous spinal anaesthesia could be devised, it would be a more useful and adaptable technique. Dean had described a technique of continuous spinal anaesthesia in 1907 [26] in which he left the spinal needle *in situ* during surgery and injected more local anaesthetic solution as and when necessary, but his technique was not widely accepted.

Lemmon published a paper in 1940 [27] describing a 17G or 18G nickel/silver alloy malleable needle and introducer with a sharp, medium-length, cutting bevel and a small opening in the long side of the bevel to enable free flow of CSF. The needle was placed in the subarachnoid space, was bent at the skin surface, and was attached to rubber tubing through which local anaesthetic solution was injected when required. The patient lay on a mattress and table that had a hole placed so as to accommodate the protruding needle. On the introduction of stainless steel, the needle was manufactured from stainless steel annealed to render it malleable (Fig. 13).

In 1943, Hingson presented his modification of the Lemmon needle [28]. The distal and proximal portions of the needle were rigid, with an annealed middle portion

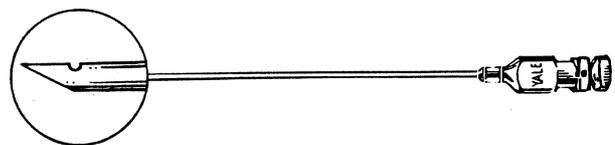


Figure 13 Lemmon needle (1940).



Figure 14 Hingson Ferguson needle (1943).

that was malleable. The tip of the needle was a short-bevelled point with a blunt cutting edge and an extra orifice near the tip. The hub had a reinforced steel collar to connect to small-bore tubing. There was a safety bead to prevent needle breakage (Fig. 14).

The continuous spinal needle had its problems and was technically difficult to use and keep in position. In 1944, Tuohy used a 15G directional spinal needle through which he passed a nylon ureteric catheter into the subarachnoid space to allow continuous spinal anaesthesia [29]. The needle had a fitted stylet with a matching bevel (Fig. 15). The medium length bevel had cutting edges. A year later, he published an article [30] describing an adaptation of his needle to incorporate a 'Huber tip', which allowed directional control of the catheter to point cephalad or caudal as required. Huber was an American dentist who had patented the tip design for hypodermic use with the aim of decreasing tissue coring on needle insertion. The original Tuohy needle had a sharp inner edge to the bevel that caused shearing of catheters, so it was modified. Over the years, other modifications were made to the Tuohy needle. One modification was the Tuohy Flowers modification, with a shorter and blunter bevel and the stylet protruding beyond the bevel of the needle to ease insertion of the point through tough ligaments (Fig. 16).

Following the introduction of the pencil-point needle for single-shot spinal anaesthesia, it was inevitable that a similar needle would be introduced for continuous spinal



Figure 15 Tuohy needle (1944).



Figure 16 Tuohy Flowers needle (1956).

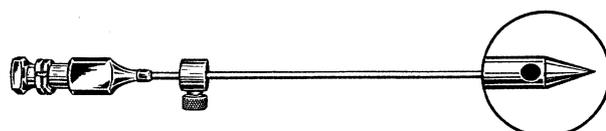


Figure 17 Cappe and Deutsch needle (1953).

anaesthesia. Although Tuohy had already introduced the idea of continuous spinal anaesthesia using catheters rather than needles, the large Tuohy needles and catheters had a significant PDPH rate, so continuous spinal needles were still in common use. Cappe and Deutsch described a malleable cone-tipped spinal needle in 1953 [31]. It was 20G in diameter and had a Whitacre tip and an 18G introducer (Fig. 17). The middle portion had been annealed to render it malleable so that the needle could be bent at the skin surface once the tip was in the subarachnoid space. There was an adjustable needle stop to stabilise the needle. They reported a PDPH rate of 6.6% in their needle group compared to 22% in the conventional cutting-tip needle group.

### The second stylet-point needle

Even after the introduction of pencil-point needles, there were still problems with spinal needles, notably loss of local anaesthetic solution extradurally with long-bevelled needles, obstruction of orifices by cored tissue and damage to neurological and meningeal tissue. Levy described his stylet-point needle in 1957 [32], 29 years after Sise first described a needle where the stylet formed the tip of the advancing needle. Levy's needle was a 20G needle with a sharp pencil-point tip that included the stylet, and which protruded 2–3 mm beyond the bevelled end of the cannula, with a smooth junction between the two (Fig. 18). On removal of the stylet, the bevelled end of the cannula was completely within the subarachnoid space without any tissue coring, with minimal damage to the dura and therefore a low PDPH rate. The Levy needle was not widely used, as the screw fixation of the stylet was cumbersome, and there were manufacturing problems in producing a smooth transition between the cannula and the stylet. However, it was theoretically an advance in design.

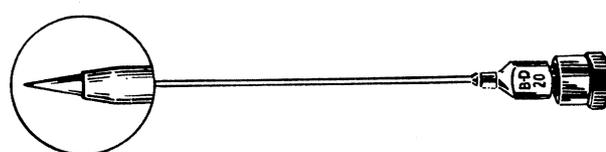


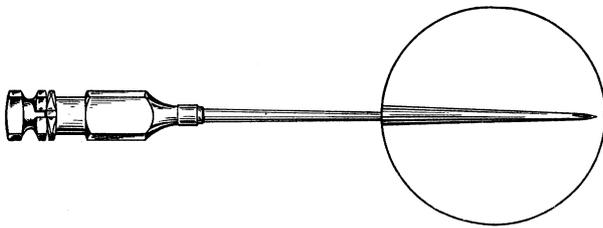
Figure 18 Levy needle (1957).

**Tapered needles**

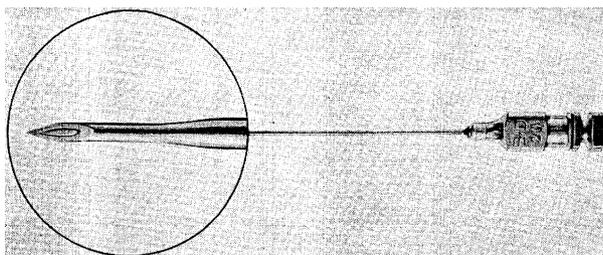
The 1960s saw some more lateral thinking in needle tip design. It had been established that smaller needles were associated with a lower incidence of PDPH, but there was a minimum diameter that was technically feasible to manufacture and use. This had been established as being 25G, but needles this fine needed an introducer, and operators found the two-needle technique cumbersome. One way of providing needle rigidity while having the finer tip was the production of a tapered needle. The cannulae were 20G at the hub, tapering to 24G at the tip. There were two designs, both of which had medium-length, cutting bevel tips and fitted stylets with matching bevels. The tapers available were either a gradual taper (Fig. 19) or a distal taper (Fig. 20). These needles failed to gain widespread acceptance for two reasons. Firstly, with the cutting bevel tip and taper there was an unacceptable PDPH rate and, secondly, the widening of the cannula proximally made it difficult to insert the larger portion of the needle through the small initial puncture hole in ligamentous structures [33].

**Disposable needles**

The 1960s saw the introduction of disposable spinal needles. The move towards finer needles had created problems in that they were easily damaged and difficult to sterilise and sharpen. Disposable needles were initially



**Figure 19** Gradual taper needle.



**Figure 20** Distal taper needle.

available only as a Quincke-type cutting tip, but the Whitacre needle was soon made available as a disposable needle. They were not initially universally accepted, as they were expensive and mass-produced with some inherent quality control issues, but as technology improved, so did the quality of the needles.

The 1970s were a relatively quiet time in the development of spinal needle design, probably due to the loss of popularity of the technique in the 1950s and 1960s. The 1970s saw an increasing use of epidural anaesthesia for surgical procedures. This replaced spinal anaesthesia to a large extent because of the greater titratability of local anaesthetic dose and the relative safety of epidural catheters. However, by the late 1980s, spinal anaesthesia was once more becoming a popular technique.

**Development of the pencil-point needle**

Thirty-seven years after Whitacre’s development of the pencil-point needle, Sprotte published his paper on a modification of the Whitacre needle [34]. The initial problems of the Whitacre needle were still evident. Sprotte modified the needle by increasing the size of the distal orifice to combat the problems of slow CSF flow, difficulty in aspiration and resistance to injection of the local anaesthetic solution. The wider hole also allowed greater mixing of the local anaesthetic solution with the CSF to allow a more even distribution of local anaesthetic solution in the subarachnoid space. The tip of the Sprotte needle was elongated in an attempt to allow more gradual separation of dural fibres and therefore less CSF leakage and a decreased incidence of PDPH (Fig. 21). Although Sprotte had a large case series, there were criticisms of his needle design. The size of the lateral hole sometimes caused the orifice to straddle the dural layers, resulting in partial loss of the local anaesthetic solution and incomplete blocks. The width of the hole also left the distal portion of the tip relatively prone to damage, including fracturing. Aglan & Stansby [35] performed flow studies of the Sprotte needle in 1992 and concluded that the needle orifice area could be decreased to the cross-



**Figure 21** Sprotte needle (1987).

sectional area of the cannula without affecting flow rate. These claims were strongly refuted by Sprotte, but the manufacturers made the recommended modifications, and by the early 1990s the Sprotte needle had been modified to the needle that is in common use today.

**Return to the cutting tip**

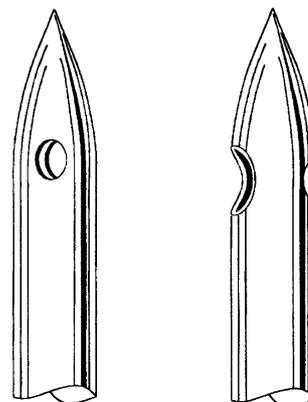
A study using the Atraucan® (B. Braun Medical, Melsungen, Germany) needle was published in 1993 [36]. The authors stated that pencil-point needles were relatively blunt, requiring force to insert them, and had a problematic distal bevel. The Atraucan needle is a return to the cutting bevel. It has a double bevel with the sharp point making an initial incision. The second part of the bevel then dilates this incision rather than cutting a larger hole, leaving only a small hole in the dura (Fig. 22). The PDPH rate was about 2.5% in initial studies, and the incidence of other complications was comparable to that using similar gauge pencil-point needles. However, the sharp tip is prone to damage.

**Double-hole pencil-point needle**

One of the criticisms of even the modified Sprotte needle was that the long lateral hole may still straddle the dura, resulting in incomplete block and loss of local anaesthetic solution. Eldor [37] suggested a design in 1996 that was based on the pencil-point tip but with two lateral holes opposite each other (Fig. 23). His theory was that the area of the two holes is equal to that of the Sprotte needle, allowing rapid flow of CSF and more even distribution of local anaesthetic solution. Injection may proceed even if one of the holes is occluded by tissue. The smaller area of the individual holes leaves the tip more resistant to deformation than the Sprotte needle. The double-hole pencil-point needle received a mixed reception due to



**Figure 22** Atraucan® needle (1993).



**Figure 23** Double-hole pencil-point needle (1996).



**Figure 24** Ballpen needle (2000).

initial manufacturing and quality control issues but still has its supporters.

**Return of the stylet-point needle**

In 2000, an article was published that described a ‘new design concept’ – a modification of a Quincke needle to make a ‘tip holed spinal needle’ [38]. This design is, in fact, very similar to that of the Levy needle of 1957, in that the tip of the needle is the tip of the stylet, leaving a hollow cannula end when the stylet is removed. Interestingly, at the same time and independently, there had been a resurgence in interest in the Levy needle design, and it is now being marketed as the ‘Ballpen® (Rusch France, Betschdorf, France) Needle’ [39] (Fig. 24). The proposed advantages of this needle are that the tip of the needle is always completely in the subarachnoid space on removal of the stylet, there is no needle tip projecting beyond the orifice to cause damage to neurological tissue and there is no mechanical weakening at the tip caused by the presence of a lateral orifice. The open end of the needle allows laminar flow of CSF, which results in faster identification of the subarachnoid space.

**Conclusions**

The history of the development of the spinal needle tip is one of trial and error, misattribution and unsolved problems. From the early hollow needles through the

cutting bevel design to the current pencil-point needles, the same initial problems are still evident today, albeit less commonly: postdural puncture headaches, failed blocks and neurological damage. We are still striving to perfect the technique of spinal anaesthesia and to find the perfect spinal needle. Perfection may lie in a modified design of the stylet-tipped needle or it may lie in a completely novel design that has not yet emerged. Whatever the final solution, it will not have been reached without using the knowledge gained over the years by the pioneering developers of the spinal needle.

Note: Further reading on the subject is provided in references (40–50).

### Acknowledgements

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