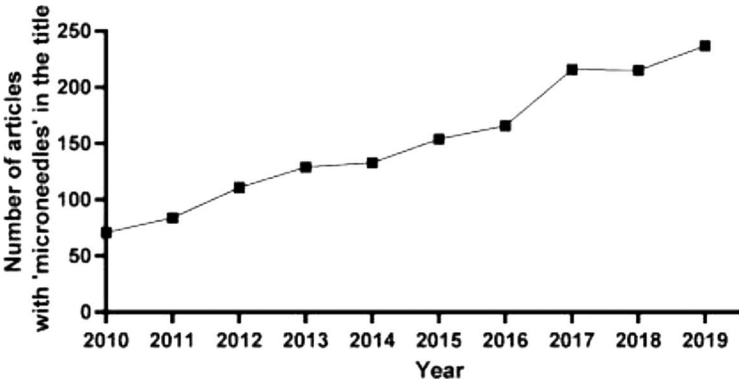

FIGURE 39.1 Number of journal articles published containing "microneedle" in the title each year since 2010. (Data acquired from PubMed (April 2020).)

Since then, there have been further advances in microengineering and polymer chemistry, leading to increasing numbers of publications (Figure 39.1), and significant progress has been made towards commercialization of this technology.

MNs combine the delivery capabilities of a hypodermic injection in the form of a patient-friendly transdermal patch. MNs minimize skin trauma and bleeding and are associated with significantly less microbial penetration than drug delivery by hypodermic injection [6]. Additionally, there are numerous reports documenting the reproducible insertion of MNs by patients (i.e., self-application) [7, 8]. Needle stick injuries are also a rare occurrence. Therefore, it can be assumed that medical personnel would not be required to administer or even supervise administration of MNs, as would be the case with a traditional hypodermic needle. There is reduced needle phobia in comparison to hypodermic needles, which should ultimately increase patient adherence to any MN device. The overriding benefit of MNs remains the promise of pain-free delivery of both small- and large-molecular-weight (MW) drugs [2].

Five types of MNs exist and are illustrated in Figure 39.2. They are solid, coated, hollow, dissolving, and hydrogel-forming MNs. Each type has advantages and disadvantages, and the most suitable type of MN for each purpose must be chosen after consideration of a number of factors, such as the drug properties and dose, among others.

Solid MNs (Figure 39.2A) typically employ a "poke and patch" technique, whereby the MNs are first applied to the skin, removed and subsequently a drug containing formulation (gel, ointment, cream, etc.) is applied to the site [10]. Drug delivery occurs via diffusion through the transient pores created in the skin by the MNs [11, 12]. The two-step process involved is the main drawback of this MN system.

Coated MNs (Figure 39.2B) are similar to solid MNs and are often referred to as the "coat and poke" approach [10]. These solid MNs are coated with a drug containing formulation prior to application to the skin. Once applied to the skin, the drug containing coating is deposited into the dermal tissue. This approach overcomes the problem of a two-step approach associated with solid MNs but is limited by the finite amount of drug that can be coated onto a MN.

Hollow MNs (Figure 39.2C) have a central bore or lumen through which drugs may pass through from a reservoir to the dermal microcirculation. Delivery of drugs via these devices may be driven by diffusion, electrical stimulation, or pressure [13]. This type of MN is capable of delivering higher amounts of drug than solid or coated MNs [14]; however, clogging of the bore/lumen or compression by the dense dermal tissue is a concern with this type of MN [15]. Furthermore, hollow MNs are often associated with bulky equipment, used to provide pressurized flow of the formulation into the skin, thus removing the advantage of convenience associated with MNs [16, 17].

Dissolving MNs (Figure 39.2D) are drug-containing MNs made of dissolving materials. As such, they may be applied to the skin in the solid state; once applied they are dissolved by the interstitial