Chapter 12
Laser and Radiofrequency Ablation Procedures

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INTRODUCTION
Several ultrasound-guided interventional procedures have been proposed to treat benign thyroid nodules without open surgery. The basic principle is to destroy thyroid nodular tissue by physical means. Percutaneous ethanol injection (PEI) was introduced in 1990 (1) and it has since proven to be very helpful in cystic benign thyroid nodules, whereas it is poorly effective in solid lesions (2,3) and is discussed in Chapter 11. HIFU (High Intensity Focused Ultrasound) is a promising new interventional US-guided technique for solid nodules (4), illustrated in Chapter 13.

RADIOFREQUENCY
Ultrasound-guided radiofrequency (RF) ablation is a method utilizing high frequency (3.8 to 4 MHz) radio wave energy to coagulate tissues. As RF energy is applied, frictional heating of tissues results, with cell death occurring at temperatures
between 60 and 100° C. RF is receiving increased attention as an effective minimally invasive approach for the treatment of patients with a variety of primary and secondary malignant neoplasms; liver tumor ablation has been the subject of most published reports (5). Some authors reported that RF may be effective and safe in treating thyroid nodules (6). However, as RF is based on the use of large needle electrodes (G 14–18), multiple needles, or hook-needles (Fig. 12.1A, B, C), RF may be too invasive for the thyroid gland, a small and delicate organ anatomically adjacent to neck vital structures. Large breaches of thyroid capsule and parenchyma caused by outsize needles may increase the risk of bleeding with sudden neck swelling and potential airway obstruction. This complication has been reported even using Fine Needle (G 22–27) Aspiration (FNA) biopsy (7). We decided not to use this method.

PERCUTANEOUS LASER ABLATION (PLA)
LASER is an acronym of Light Amplified Stimulated Emission of Radiation. Optical fibers deliver high energy laser radiation to the target lesion. Neodymium:yttrium aluminum garnet lasers (Nd:YAG), with a wavelength of 1064 nm, are used for PLA because penetration of light is optimal in the near-infrared spectrum. In recent years, diode lasers with suitable wavelength have also been used. The penetration of laser light is only a few millimeters as a result of scattering and absorption. Scattering results in a relatively uniform distribution of absorbed energy, and heat is produced by conversion of absorbed light (8, 9). Temperatures greater than 60° C result in rapid coagulation necrosis. Irreversible cell death, without preceding coagulation, also occurs at lower temperatures (40–45° C), but requires duration of treatment that inversely correlates with temperature (8, 9).

The first report of percutaneous laser ablation (PLA) on human thyroid tissue is by Pacella, et al. (10). In Reggio Emilia, we started to use PLA in patients with benign thyroid cold nodules in 2002. Since then, several studies have been published confirming effectiveness and safety of this new technique (11–19).

Fig. 12.2 shows macroscopic changes occurring in a thyroid nodule resected one month after laser ablation. Nodule section shows tissue degeneration and necrosis with tissue carbonization (arrows). Vaporization and charring are consequences of tissue overheating. Plane-cut tip fibers achieve temperatures up to 180–200° C where fibers are in direct contact with tissue. Microscopically (Fig. 12.3), laser ablated areas are characterized