In 1932, Hyman invented an external cardiac stimulator to electrically stimulate the heart from outside the body using a needle electrode. He named this stimulator an “artificial pacemaker”, which is the name still generally used. In 1958, Åke Senning, a thoracic surgeon at the Karolinska Hospital in Stockholm, implanted myocardial electrodes and a pulse generator with a rechargeable nickel-cadmium battery in a 40-year-old patient using an open thoracotomy, and in 1958. Furman et al performed endocardial pacing using an external pacing device, and a prototype of the current VVI pacemaker was developed in 1963. After this, the transvenous approach became popular and implanting pacemakers has become a key technique for surgeons during challenging procedures.

Pacemakers were mainly used to treat bradycardia in the clinical setting, and the primary challenge was to ensure pacing without any problems such as lead fractures or dislodgment, threshold changes and early battery depletion, thus technical improvement was promoted. Regarding the pacemaker body, efforts were made to reduce its size and prolong the battery life with technological developments. Alongside pacemaker therapy, many advances have been made in the understanding of arrhythmias. The older generation leads showed easy dislodgement or displacement, a high rate of fracture and inflammation at the tip of the electrode with increasing pacing thresholds, causing premature battery depletion and problems. The structure and materials of the electrode have been variously changed, from bare-metal electrodes to porous electrodes with a lower tendency to dislodge and showing improvement in pacing threshold. As electrode tip materials, titanium, iridium, and vitreous carbon have been in use. The conductor coils were designed to improve tensile strength and increase resistance to fractures, but chronic threshold increase was
another issue to be solved until the innovation of steroid-eluting electrodes. Current steroid-eluting electrodes approach ideal performance with low stable thresholds (Figure).3,6

The other issue has been dislodgment of the electrodes. The development of active lead fixation with the use of a deployed helix has dramatically lowered the incidence of lead dislodgment.7 Although equivalent to passive fixation in long-term stability, active-fixation leads allow more choice in implant site selection and may be more amenable to lead extraction as Oginosawa et al8 in this issue of the Journal and others have reported.9 A lead structure with the combination of active fixation and steroid-elution is now available for worldwide use. In a sense, the combination is ideal as an endocardial pacing lead tip because of easy implantation, good acute phase performance,10 and secure long-term pacing threshold.11 However, it is known that active-fixation screw-in leads are associated with initially high pacing threshold because of inflammatory or traumatic response of myocardial tissue around the screw. This sometimes makes it difficult for the physician to decide whether to anchor the electrode tip at the site.

As performed by Oginosawa et al,8 we also usually map the endocardium to identify the best site for pacing, with the tip of electrode remained retracted, by checking the pacing threshold, sensing amplitude and lead impedance. If the condition of the lead tip was difficult, as they encountered, the lead is suspected to have some problems, and should be replaced with a new one. So Oginosawa et al8 changed the electrode and repeated the procedure, with same results. However, they had achieved good contact between the screw and the myocardium after screwing in the second electrode, and the condition was improved. From this experience they tried to work out why the impedance was so high before extension of the helix. Their experiment was designed to elucidate the reasons and proved that the air bubble surrounding the helix in the silicone rubber collar interferes with the electrode contacting the tissue or blood until it is screwed in. The electrode Tendril MRI™ LPA 1200M (St. Jude Medical, St. Paul, MN, USA) is newly developed for MRI conditioned pacemaker systems and the silicone rubber collar material is used to protect myocardial tissue, protect the screw before extrusion and reduce tip pressure to avoid perforation.12 The manufacturer originally designed the electrode tip structure for mapping in the Tendril ST Optim lead (St. Jude Medical), and stated that with the active mapping collar it would enable the physician to take threshold measurements prior to extending the helix, which was designed to save time extending and retracting the helix while searching for an acceptable location.13 However, the active mapping collar was not used with the electrode of the Tendril MRI™ LPA 1200M, which was a pitfall of the structure that does not always work as designed, even though the structure of the electrode tips is almost the same. Is this “Trick or Treat”? It is now late 2014 and at last it is being recognized how leads play a critical role in the reliability of a pacing system. Understanding how the design and structure of leads influence their potential performance and reliability is important. We have to know the structure of the leads that we are using. And we have to be aware that the structure does not always work as designed or intended.

References