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## Stent: The Man and Word Behind the Coronary Metal Prosthesis

Ariel Roguin, MD, PhD

Interventional cardiologists implant stents every day. Stents are also used in numerous other medical disciplines such as plastic surgery, gastroenterology, urology, and oral and maxillofacial surgery.<sup>1-5</sup> Uses range from rebuilding mandibles and other oral surgical procedures, constructing new ureters, keeping skin flaps, and as biliary conduits.<sup>6-11</sup> What is the source of this word *stent* everyone is using in daily practice? This article describes the origin of the word, how it became so popular, its use in medicine outside the cardiovascular system, and the people who used this term first.

### Charles Thomas Stent: An English Dentist

The current acceptable origin of the word *stent* is that it derives from the name of a dentist. Charles Thomas Stent (1807 to 1885) was an English dentist notable for his advances in the field of denture-making. He was born in Brighton, England, on October 17, 1807 (Figure 1), and was the 6th son of William and Hannah Stent. He was a dentist in London and is most famous for improving and modifying the denture base of the gutta-percha, creating the Stent's compounding that made it practical as a material for dental impressions. His accomplishments led to his appointment as Dentist to the Royal Household in 1855.<sup>1-4</sup>

Gutta-percha is a natural latex produced from tropical trees native to Southeast Asia and northern Australasia. In 1847 it was introduced as a material for making dental impressions. It was used to fill the empty space inside the root of a tooth after it has undergone endodontic therapy. Interestingly, this same material was also used for furniture, and, because of its good electric insulation properties, it was used also to insulate telegraph wires. Gutta-percha served as the insulating material for some of the earliest undersea telegraph cables, including the first transatlantic telegraph cable.

However, in dentistry this material was unsatisfactory for several reasons, including its tendency to distort on removal from the patient's mouth and to shrink on cooling. In 1856, Charles Thomas Stent added several other materials to the gutta-percha, notably stearine, a glyceride of stearic, palmitic, and oleic acids, a substance derived from animal fat that markedly improved the plasticity of the material as well as its stability. He also added talc as an inert filler to give more body to the material and added red coloring.

He and his wife Caroline had 2 sons and a daughter, Fanny. Both his sons, Charles R. Stent (1845 to 1901) and Arthur H. Stent (1849 to 1900), became dentists, and together they founded a firm, C. R. and A. Stent, which manufactured the increasingly popular Stent's Compound. Charles T. Stent died in 1885 and was buried in London. The sons continued marketing the compound through the prestigious dental supply company, Claudius Ash and Sons of London. When the last of the Stent brothers died in 1901, Ash's firm purchased all rights to the compound and manufactured it, keeping the Stent name (Figure 2). Claudius Ash and Sons became an international company, in 1924 merging with de Trey & Company to form the Amalgamated Dental Company; it is now a division of Plandent Limited.

### Early Use of Stent's Name in Surgery

The transition of the dental impression compound into a surgical tool is attributable to Johannes Fredericus Esser (1877 to 1946), a Dutch plastic surgeon who pioneered innovative methods of reconstructive surgery on soldiers with face wounds during the First World War. This war saw the introduction of trench warfare. Soldiers in the trenches were fairly well protected so long as they stayed below ground level. To fire their rifles, however, they had to raise themselves above the edge of the trench and thus were very susceptible to facial wounds. The number of these disfiguring wounds was staggering, and surgeons had little experience in handling them.<sup>1-3,7</sup> Esser was designated Special Surgeon for Plastic Operations and assigned to a hospital in Vienna. He applied sterilized Stent's dental mass to stabilize the skin grafts. In 1917, he described his experience with these wounds and how he used "the mold of dentical mass (Stent's) in fixation of skin grafts in oral surgical repair of war wounds."<sup>12</sup> This he accomplished by means of what he termed the "epidermic inlay technique," which used Stent's compound to stretch and fix in place grafts to enlarge the conjunctival opening and in ear reconstruction as well as intraoral grafting. Later in the article, he simply called it "stents mold," without a capital letter. Interestingly, his monograph also dealt with hypospadias repair.

An English army surgeon, H.D. Gillies, cited Esser's work in his 1920 book, *Plastic Surgery of the Face*, when he wrote

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**Figure 1.** Charles Thomas Stent (1807 to 1885). Image courtesy of the *Journal of the History of Dentistry*.

“The dental composition for this purpose is that put forward by Stent and a mold composed of it is known as a ‘Stent’.” This is probably the first use of Dr Stent’s name as a noun.<sup>13</sup> The principle of the fixation of skin grafts by “stenting” was quickly adopted and persisted long after Stent’s compound ceased to be the material of choice for this technique.<sup>7</sup>

### Stents in Noncardiovascular Fields

The application of the word *stent* in the surgical literature was not immediate. Since the beginning of the 20th century, numerous inert tubes and biological tissue to bridge a gap or restore bile duct continuity were tested. Such a device was referred to in various ways: tube, catheter, internal splint, internal strut, and later, endoprosthesis. The first reference to a polyethylene tube “to act as a stent for the anastomosis” in experimental biliary reconstruction in dogs was made in 1954.<sup>14</sup> ReMine recalls that, “because he was using a skin graft for a conduit, he wished to prevent contraction of the skin graft, and hence the principle of Stent’s dressing was extended to a tubular structure.”<sup>22</sup> In 1966, Menick and Kim<sup>15</sup> reported on a patient in whom a rubber tube had been left in situ in a repaired common bile duct for 27 years. The text described the tube as “a splint and prosthesis,” but the title of the article used the term *stent*.



**Figure 2.** Logo stamp of the Stent compound when manufactured by Claudius Ash and Sons. Image courtesy of the *Journal of the History of Dentistry*.

In urology, even as genitourinary reconstruction of the ureter and urethra expanded in the first half of the 20th century after World War I, the terms used were *tube*, *catheter*, and specifically, *retention catheter*. After World War II, the terminology remained limited to ureteral, urethral, and vassal splinting.<sup>8</sup> Because the spoken word generally precedes the written word, it is reasonable to suppose that some urologists must have started to use the word *stent* once it was established in the surgical vocabulary.

In urology, stenting first appeared in 1972, when Goodwin<sup>16</sup> wrote a brief commentary titled *Splint, Stent, Stint*, concluding: “Urologists are always talking about putting a tube in a ureter or urethra. When they do this, it is not a splint. It may be a stent. It probably is never a stint. Perhaps the process is most properly described as leaving a tube or stent in an organ.” Firlit and Brown,<sup>17</sup> also in 1972, made the switch from *splint* to *stent*. Montie et al<sup>18</sup> commented specifically on their terminology:

Since there has been considerable confusion in the literature in reference to the words “splint,” “stent,” and “stint,” brief reference is made here to the reason for choosing the word “stent” in these experiments. As described succinctly by Goodwin in 1972, a splint is something that is put outside a structure to make it stable, whereas a stent is a compound, or a mold made of a compound, for holding some form of a graft in place. When referring to an intraluminal device to maintain patency until healing has taken place, the word ‘stent’ is most appropriate.

By 1980, the urinary tract stent was widely in use in adult and pediatric urologic practice and was also the word used for hypospadias repair, similar to the work described by Esser in 1916.<sup>12,19</sup>

In the second half of the 20th century, stents were used in a variety of surgical terrains, including nasal surgery stents, spiral Teflon stents for gynecologic tuboplasty, T-tube tracheal stents, skin graft stents for mandibular reconstruction, and

flexible stents for heart valve fabrication.<sup>20–24</sup> Today, stents and stenting became frequent in vascular surgery, gastrointestinal surgery, radiology, cardiology, neurosurgery, thoracic surgery, and other medical specialties.

### First Citation in Cardiology

The first reference in the cardiovascular literature of the word *stent* was by Weldon et al<sup>25</sup> in 1966, when they described a prosthetic-stented aortic homograft used for mitral valve replacement. Weldon was aware of the use of the word *stent* by plastic and oral surgeons and assumed that it was an all-purpose term for “any kind of nonbiological support used to give shape or form to biological tissue.”

What about the coronary stent as we know today? In the original article from 1964 by Dotter and Judkins<sup>26</sup> on “dottering,” the authors alluded to the promise of these endovascular devices, yet they termed them “a manually guided dilator” or “a device suitable for percutaneous insertion, which is a functional equivalent of the present spring guide but capable of externally controlled concentric expansion over a suitable portion of its length.” However, Dotter and Judkins did not use the word *stent* in print until 1983.

Dotter was the first to use the word in his article in *Radiology* in April 1983, which was titled “Transluminal Expandable Nitinol Stent Grafting: Preliminary Report.”<sup>27</sup>

The first coronary stent was implanted into a patient by Jacques Puel in Toulouse, France, on March 28, 1986.<sup>28,29</sup> In their report in French, they used the term *endo-prothèses coronariennes autoexpansives*.

Ulrich Sigwart has been credited with the concept and realization of endoluminal stenting, a procedure that has revolutionized coronary and peripheral arterial revascularization.<sup>30,31</sup> Sigwart worked at the University Hospital, Lausanne, Switzerland (1979 to 1989), and played a pivotal role in the concept and ultimate application of coronary stenting.

Jacques Puel and Ulrich Sigwart were invited almost simultaneously by the company Medinvent to help with the initial animal and clinical research pertaining to their new product, the Wallstent. Ulrich Sigwart was contacted because he practiced in Lausanne, Switzerland, the headquarters of Medinvent, and the French engineer behind the product contacted his French colleague, Jacques Puel.

Sigwart and Puel were the first to report on the clinical use of stents to prevent sudden occlusion and restenosis after transluminal angioplasty in their landmark work published on March 19, 1987, in the *New England Journal of Medicine*.<sup>32</sup> The article reported their experience from Lausanne, Switzerland, and Toulouse, France, of 10 stent implantations in 6 patients for iliac or femoral arterial disease; 24 coronary artery stents implanted in 19 patients who presented with coronary artery restenoses (n=17) or abrupt closure (n=4) after transluminal angioplasty or deterioration of coronary-bypass grafts (n=3).

Sigwart also observed the shortcoming of stents when, 3 months after one had been implanted in the proximal left anterior descending artery, the patient had recurrent chest pain. Angiography revealed severe restenosis, and he wrote that a combination of mechanical and biological factors

would be the *sine qua non* to overcome the problem of recurrence.<sup>33</sup>

Sigwart wrote in a letter to the editor<sup>34</sup> of the *American Journal of Cardiology* that, “When submitting the first article on human stenting in 1986, the *New England Journal of Medicine* persuaded me to drop the verb ‘stenting’ and use instead the noun ‘stent.’”

In parallel, in the United States, several groups were actively developing and testing these devices in the coronaries.<sup>35</sup> Julio Palmaz, an interventional vascular radiologist, is known for inventing the balloon-expandable stent, for which he received a patent filed in 1985. This patent has been included on the list of the 10 most important inventions of all times. Julio Palmaz born in La Plata, Argentina, and Richard Schatz, a cardiologist from the Brooke Army Medical Center, worked together in the University of Texas Health and Science Center at San Antonio. They miniaturized the Palmaz balloon-expandable stent for coronary use and performed extensive animal studies. In October 1987, Palmaz implanted his first peripheral stent in a patient at Freiburg University in Germany. Later that same year, the first Palmaz-Schatz coronary stent was implanted in Sao Paulo, Brazil. Both procedures were very successful. At the same time, another group in Emory University, Atlanta, Georgia, led by Gary Roubin and Spencer B. King III, used a device pioneered by Cesare Gianturco, a creative Italian radiologist who also developed tools such as occlusive coils and vascular filters.

Both of their seminal reports appeared in *Circulation*.<sup>36,37</sup> The Gianturco-Roubin Flex-Stent and the Gianturco-Roubin (GR II) Coronary Stents (Cook Inc) were the first Food and Drug Administration–approved coronary artery stents in February 2002. The Palmaz-Schatz stent did not get approved until 1994, after the BENESTENT and STRESS randomized trials, comparing stents with balloon angioplasty. Within 4 years of Food and Drug Administration approval, the balloon-expandable stent was used in >80% of percutaneous coronary interventions, a virtually unparalleled success.

### Older Origins of the Word *Stent*

According to the medical dictionaries,<sup>38–40</sup> the word *stent* is much older than Charles Stent and is derived from an old and long-forgotten Scottish word for extend, set, or stretch out as a sail. According to the *Oxford English Dictionary* Word and Language Service, the word *stent* has already been used in the 14th century.<sup>38</sup>

The noun *stent* refers to a stake for stretching out fishing nets on a river. Furthermore, it could also be used as a verb in the context of stretching out sails, curtains, or fishing nets. In addition, it has been used to describe the act of stiffening a garment; an assessment of property for the purposes of taxation; and tin-mining rubble. Most of these forms are Scot or obsolete and are derived from the Old French *estente*, meaning extent.

Hedin<sup>3</sup> questioned whether the Stent family name might have been derived from the obsolete English and Scottish meaning; however, Sterioff<sup>2</sup> researched the family name Stent, and, according to The Historical Research Center, there is no connection of the surname and the ancient meaning.

In summary, all the evidence has it that Charles T. Stent gave his name to our coronary endovascular prosthesis (the stent), and Charles T. Dotter was the first to use the name in a publication. Eponyms have long been commonplace in medical practice. Very rarely, however, does a name, standing alone, become part of the living language.<sup>41</sup> The word *stent*, used both as a noun and a verb, is just such a case. The greatest tribute that can be given to any inventor is to have the initial capital letter dropped from his or her name changed to lowercase and the name itself to a verb. That is the ultimate recognition that the word is now in the general language.

## Disclosures

None.

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