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SCIENTIFIC SECTION

A 100th anniversary: Sandstedt's experiments on tissue changes during tooth movement

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In 2004, it is 100 years since the experiments by Carl Sandstedt on tissue changes during orthodontic tooth movement were published in an international journal, shortly after his early death.

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'Some contributions to the theory of tooth movement'

Standstedt's experimental studies of tooth movements in dogs were first published in Swedish in 1901 as a report from the Anatomy Department at the Karolinska Institute in Stockholm.[1] The title of the report in English was 'Some contributions to the theory of orthodontic tooth movement'. It was presented to an international public in a slightly shortened version in German as three papers in the *Nordisk Tandläkare Tidskrift* 1904–1905,[2] shortly after his death. In these papers an extensive literature review from his first report was omitted.

Sandstedt did his experiments in dogs. The quality of these early studies is reflected in his addition of a control animal from the same litter as one of his two experimental dogs. In the experimental animals a sectional fixed appliance was inserted in the upper jaw, allowing repeated activations for palatal tipping of upper incisors over a 3-week period. Stained histological horizontal and sagittal sections of the incisor areas were prepared. In order to document positional changes of the teeth not only were plaster casts taken, but also radiographs (and this less than 5 years after Röntgen's discovery of X-rays!).

In the controversy of tooth movement as a remodeling process versus an explanation by bone elasticity, Sandstedt convincingly demonstrated, apparently for the first time, tooth movement as a process of resorption and apposition. The interplay between resorptive and appositional processes in the alveolar bone during tooth movement is perceived: 'the (alveolar) wall appears to move' as apposition on the alveolar side is balanced by resorption in adjacent vascular spaces and vice versa (Figures 1–2). In sections of the incisors and a canine tooth, new bone formation was shown in areas of tension, and resorption was demonstrated in areas of compression ('pressure zones'), all in line with a tipping movement of the teeth, as concluded from X-rays and casts. In the compressed periodontium, he gives the first description of a *hyaline zone* developed during tooth movement: 'an obviously degenerated product, a hyaline transformation of the connective tissue, in which regenerative processes take place ... the old mortified tissue is resorbed and substituted by granulation tissue ...'. He further notes that 'at the limit of the hyaline zone the alveolar wall presents a deep, *undermining notch* filled by proliferating cells as in resorptive areas'. Furthermore, '... the intensive resorptive process *even attacked the incisor* itself.. deeply into the dentine..', and he supposes this to be a common secondary effect to orthodontic tooth movement (Figure 3). Many of the major tissue changes at a light microscopic level that are described in orthodontic textbooks of today, including root resorption, were thus demonstrated by Sandstedt in his report.

In his report, Sandstedt stated that four ongoing experiments were yet to be completed, which is why we conclude from the publication in 1904-05 that his project was not ended. His observations and thoughts, however, probably heavily influenced researchers publishing studies on tissue changes during tooth movement shortly after his death, for example, Oppenheim in Germany.

Carl E. Sandstedt was born in 1864 in Växjö, Sweden.[3] In 1892 he published the first epidemiological study in the field of dentistry in Sweden ('Undersökning av

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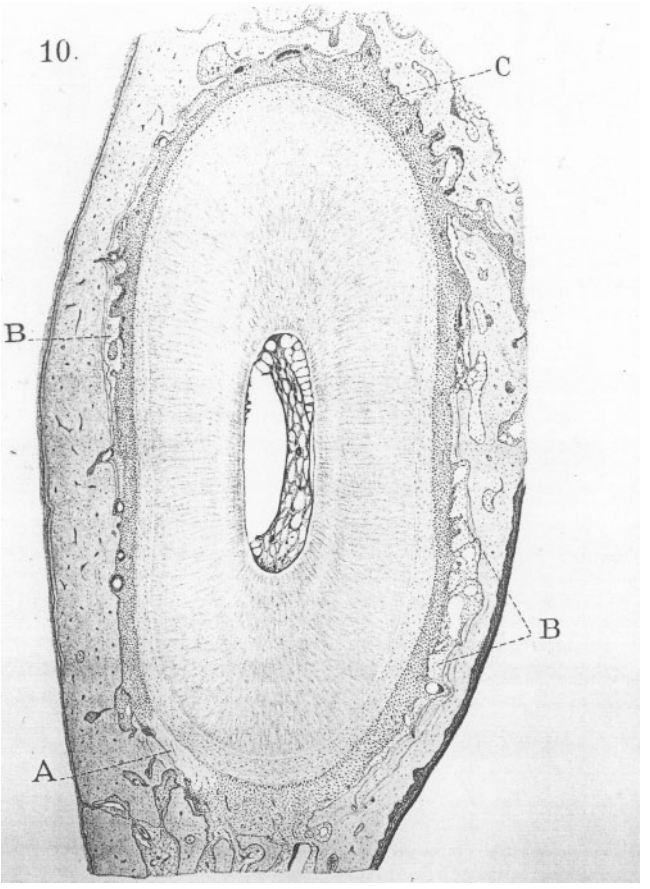

Figure 1 Horizontal section through a cuspid tooth of an experimental animal demonstrating appositional, as well as resorptive surfaces. At **A** (mesially-palatinally) a degenerative change in the periodontium, which has resulted in sclerotic and hyaline transformation of the periodontal membrane

skolbarns tänder'/'A study of the teeth of school children'). He became a prominent member of the Swedish Dental Society, where he devoted heavy commitments to the issue of training dentists. In his commissions for the society, as well as during his visits to European dental schools he established several bonds of friendship with international colleagues. Active in business, as well as his dental profession, he died at the age of 40 in 1904. The year before he had achieved a position as head teacher in Prosthetics and Orthodontics at the new Dental Institute associated with the Karolinska Institute in Stockholm.

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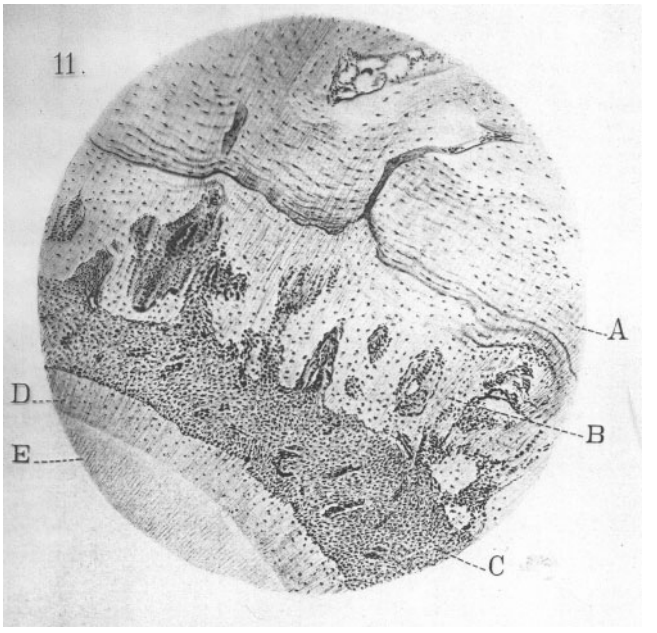

Figure 2 Cuspid tooth, appositional zone. Older lamellar bone (**A**), radially projecting new bone (**B**) towards root cement (**D**)

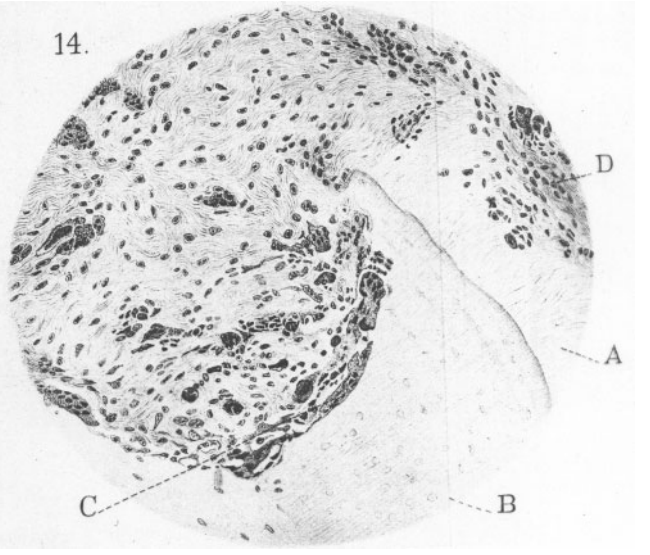

Figure 3 Multinuclear cells (**C**) resorbing root cement (**B**) close to a sclerotic area of the periodontium (**A**)

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