Early Designs for the Occlusal Anatomy of Posterior Denture Teeth: Part III

Robert L. Engelmeier, DMD, MS

Part III of this series of articles, like Part II, reviews the pioneering efforts in the 19th century to improve the quality of artificial teeth. The focus of this article, unlike that of Part II, is specifically modifications in the design of the occlusal anatomy of the 19th century denture teeth, along with the theories of mandibular movement that inspired those modifications. This article concludes the introductory phase of this project, which seeks to unravel the confusing history of the development of (posterior) denture teeth.

J Prosthodont 2005;14:131-136.

INDEX WORDS: denture occlusion, artificial teeth

THE OCCLUSAL designs of artificial posterior teeth prior to 1913 were all arbitrary carvings. Throughout the 19th century, innovative individuals studied and analyzed the complex movements of the mandible. Many of them further attempted to develop instruments/articulators to simulate those jaw movements. By the end of the century, some understanding of the excursive movements of the jaw had emerged, but a thorough understanding of the complexities of mandibular movement and the development of 3-dimensional instruments would have to wait for the 20th century. Until the turn of the 20th century, it had not occurred to anyone to carve the master patterns for anatomical posterior denture teeth on an instrument that had been programmed with average control settings. Only then would it be possible for anatomical artificial teeth to be set in harmony with a patient's determinants of occlusion. Only then could the teeth be set to balance and be free of interferences during functional as well as parafunctional movements. Work began as early as the mid-19th century to understand mandibular movement and to develop instruments to duplicate it. These early efforts eventually enabled the celebrated Dr. Alfred Gysi to make his great contributions in this area. He introduced his 33° anatomic teeth in 1913.

Director, Graduate Prosthodontic Program, University of Texas-Houston Dental Branch, Houston, TX.

Accepted March 30, 2004.

Correspondence to: Dr. Robert L. Engelmeier, University of Texas-Houston Dental Branch, 6516 MD Anderson St. Rm 429C, Houston, TX 77030-3402. E-mail: rengleme@mail.db.uth.tmc.edu

1059-941X/05

doi: 10.1111/j.1532-849X.2005.00001.x

Claudius Ash

Claudius Ash and Sons' early posterior denture teeth, though they were among the best teeth available at the time, had very crude occlusal anatomy and were unglazed (Fig 1A).[1] There was no difference between maxillary or mandibular teeth or, for that matter, teeth meant for the right or the left side. Molars were indistinguishable from premolars. Cusps were blunted, poorly defined, and probably not very efficient (Fig 1B).[2]

As early as 1858, the Ash and Sons Company produced an obviously nonanatomical tooth (Fig 1C).[2] The occlusal design of this tooth sought to gain a mechanical advantage over the "anatomic" teeth commercially offered at the time. This "inverted cusp" design, according to Craddock,[2] had no particular philosophy behind its design, nor did it attract particular attention by the profession. Apparently, this design quickly faded into obscurity. Sears[3] later pointed out the striking similarity between this tooth and Rupert E. Hall's Inverted Cusp Teeth of 1931.

Between 1870 and 1890, Ash's teeth evolved to the point that there were clear distinctions between maxillary and mandibular teeth, as well as teeth intended for the right and left sides. Molars, finally, were carved and proportioned distinctly different from premolars. Instead of "inverted cusps," Ash's teeth of the late 19th century

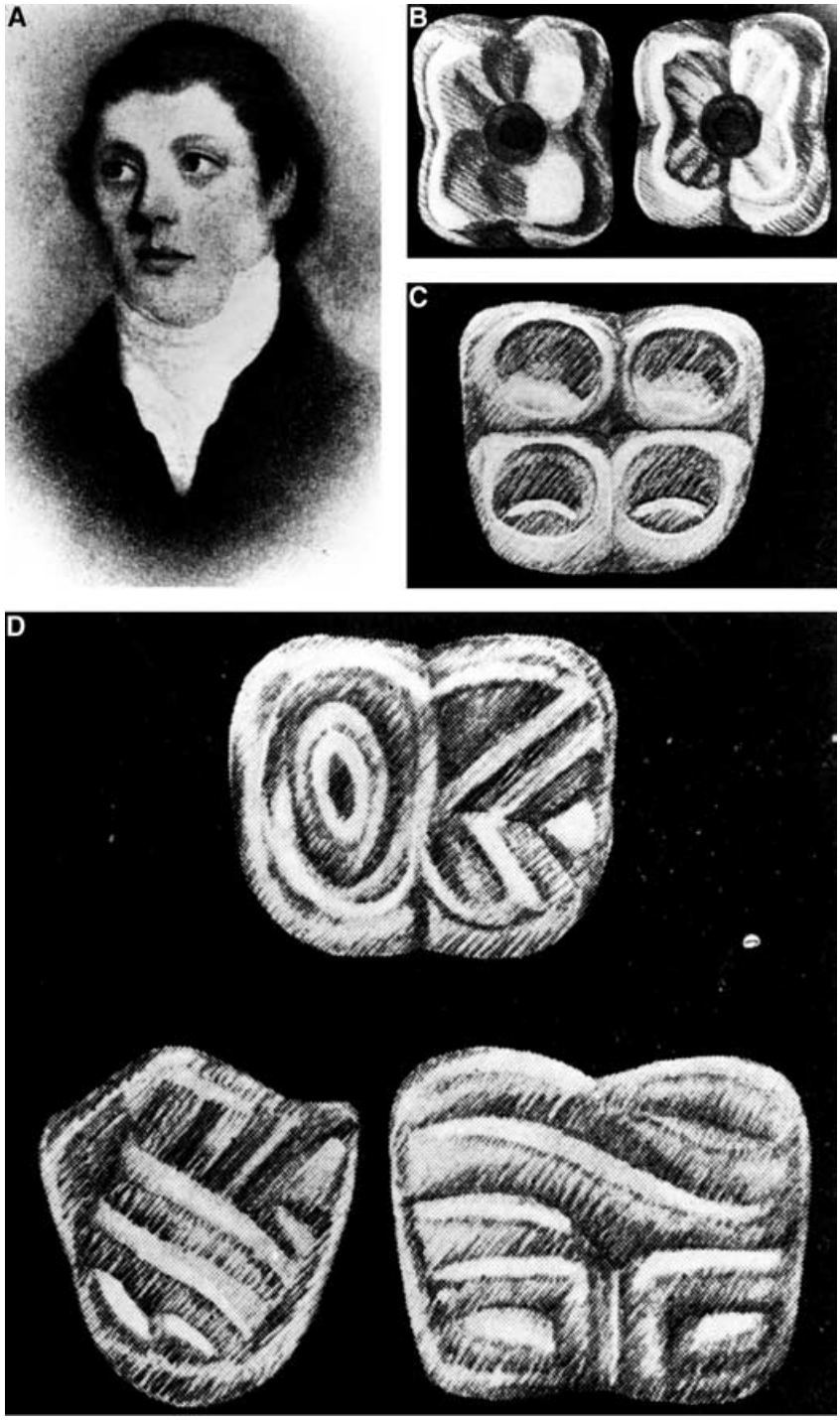

Figure 1. (*A*) The porcelain denture teeth of Claudius Ash, pictured here, were among the best available during the 19th century. (*B*) The early posterior porcelain teeth of Claudius Ash were unglazed and crudely carved. (Courtesy, the Editor, *New Zealand Dental Journal*). (*C*) Claudius Ash and Sons Company produced nonanatomic teeth with "inverted cusps" as early as 1858. (Courtesy, the Editor, *New Zealand Dental Journal*). (*D*) Another nonanatomical tooth design produced by the Claudius Ash and Sons Company during the late 19th century.[1] The designer is unknown. (Courtesy, the Editor, *New Zealand Dental Journal*).

displayed sharp ridges and grooves traversing their occlusal surfaces (Fig 1D).[2] The individual teeth, however, were still disproportionate in their dimensions.[1] The occlusal ridges and grooves illustrated in Figure 1D[2] curiously resemble some of the nonanatomic occlusal designs developed in the 20th century.[3] These design modifications of Ash's teeth may have enhanced their masticatory efficiency, but they were not based on any particular philosophy of mandibular movement or occlusion.

Francis Hancock Balkwill

Francis H. Balkwill did not design an occlusal form for posterior denture teeth. Instead, he developed a system for reshaping (by selective grinding) the crude, block-like, porcelain posterior teeth that were commercially available at the time. The purpose of his technique was to produce an occlusion free from cuspal interferences and capable of efficient mastication.[3–7]

In 1866, Balkwill presented an insightful paper to the Odontological Society of Great Britain.[5] His dissertation began with astute observations of the comparative dental anatomy of the teeth of humans and various animals. Of particular importance was his lucid observation of how the occlusal anatomy of opposing teeth functions in harmony during excursive movements of the mandible. He proposed that each unique feature of a tooth's occlusal anatomy had a distinct purpose (or function). Though Balkwill's observations were brilliant, the profession has, for the most part, failed to recognize his genius and has not given him due credit.[6] In his 1866 paper,[5] Balkwill presented important occlusal concepts that were ignored and lost for decades, only to be "rediscovered" and credited to others. Finally, in 1912, the eminent Alfred Gysi[7] reviewed Balkwill's paper and applauded him for his understanding of occlusion and articulation. Fereday,[6] in his article, reviews the landmark discoveries credited to others over the past 135 years which were actually described by Balkwill in 1866. Pause must be taken here to review some of these revelations.

Through his 1866 dialogue and drawings, Balkwill demonstrated an understanding of the downward and forward movement of the mandibular condyle as well as the function of the articular eminence. Credit for this understanding has long been given to William E. Walker[6,8,9] in 1896 and Charles E. Luce[6,10] in 1889. Balkwill's illustrations clearly demonstrate what Poselt[11] called "Christensen's Phenomenon" named after Carl Christensen. Nearly 40 years prior to Christensen's paper,[12] Balkwill designed an articulator, which he referred to as a "bite frame,"[5] and which sounds like a face bow, to relate the maxillary ridge to the condyles. In addition, he developed a device to measure the angle of the eminence.[5,6] Unfortunately, no examples or drawings of those instruments are known to exist.[6] Neither are there any pictures of Balkwill himself to be found.

Incredibly, Balkwill described what is now known as the "Side Shift" of the mandible, or "Bennett Movement," more than 4 decades prior to Norman G. Bennett's paper of 1908.[13] In spite of Hall's[14] attempt to assign Balkwill's name to this movement, the term "Bennett Movement" has persisted.[6]

Balkwill called the canines "guide posts"[5] and very clearly understood their role in a mutually protected occlusion. Levin,[15] in his 1989 paper, credits A. d'Amico[16] for discovering this principle since he described it in his 1958 article (Fig 2A).[5]

According to Fereday,[6] Gysi pointed out that Balkwill recognized the occlusal compensating curves later rediscovered by Spee in 1890, Christensen in 1905, and Monson in 1920. Balkwill's illustrations had shown the entire frontal section/plane instead of just one side, he also would have demonstrated the Curve of Wilson.[6] Balkwill's illustrations include the dynamic functional paths of the occlusal surfaces of the mandibular teeth during the excursive movements of the jaw, superimposed on a view of the mandible (from below). This drawing clearly shows the gothic arch-shaped functional paths formed between opposing teeth during movement (Fig 2B).

Balkwill even described the function of the finer details of the occlusal anatomy of the posterior teeth, i.e., marginal ridges and sleuce ways.[5]

The point of Balkwill's astute observations and his landmark paper was to give clinicians a system to customize (by selective grinding) the crude posterior denture teeth of that era, as well as an understanding of mandibular movement and occlusion to support his system of reshaping the teeth. His method created an anatomy, which was closer to the natural dentition. Balkwill established 5 rules to achieve a harmonious occlusion. His grinding/reshaping technique was based on those 5 rules. Ultimately, Balkwill hoped

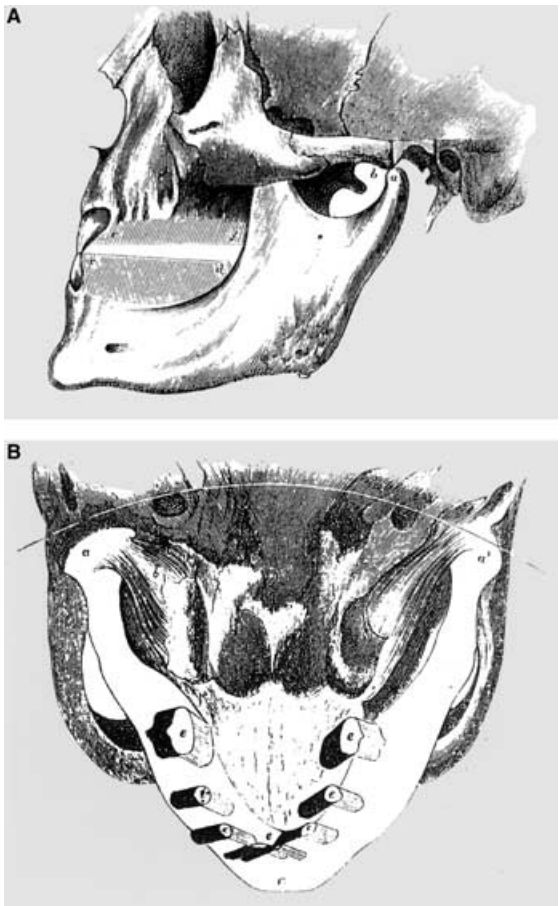

Figure 2. (*A*) This illustration from Balkwill clearly demonstrates the function of the articular eminence and the function of the canines as "guide posts." (*B*) This illustration from Balkwill shows the Gothic arch-shaped functional paths of the occlusal surfaces of the mandibular teeth during excursions of the jaw.

his technique would influence the manufacturers of artificial teeth to improve their designs of the occlusal anatomy of commercially available teeth.[5]

W. G. A. Bonwill

W. G. A. Bonwill[1] (Fig 3A) was one of dentistry's more colorful and inventive members. Though he is credited with a number of dental inventions, he is best known for his articulator (Fig 3B) of 1858 and his geometric theory of occlusion. Though his writings appear a bit pompous, and sound more like soliloquies than scientific papers, Bonwill made a significant contribution to the profession, nonetheless. Bonwill did not design any posterior denture teeth. Like Balkwill, he proposed a method for reshaping (by selective grinding) the commercially available teeth of the time. His goal was to achieve a harmonous occlusion free of cuspal interferences during the excursions of the mandible. He based his technique on his geometrical and mathematical approach to occlusion. Bonwill believed that mechanics (i.e., mathematics and geometry) formed the basis of the anatomy and function of the jaws and teeth. Central to his theory was an equilateral triangle formed between the 2 condyles and the incisal edges of the mandibular central incisors at the midline. On average, this triangle measured approximately 4 in. on each side. Space does not allow a review of Bonwill's Theory and Technique. In his writings,[17] he gave very explicit instructions for grinding the posterior denture teeth. He was exacting in reshaping the teeth to achieve balance while eliminating interferences. Bonwill ground anterior–posterior channels in the molars, but for some reason did not do this to free the mandible in a protrusive movement, because he did not cut similar channels into the biscuspids (Fig 3C[3]). In his epistles to the profession, Bonwill lays out his "Philosophy of Mastication" with a flair and drama akin to that of Moses, stone tablets in hand, descending Mount Sinai. As a footnote, Bonwill supposedly was a close friend of the legendary P. T. Barnum. This fact, and Bonwill's incredible writing style, makes one ponder which of this pair most influenced the other.

Summary

As reported in Part II of this introduction, 19th century Philadelphia was America's mecca for artificial tooth production. A number of the most prominent denture tooth manufacturers were headquartered there. Competition between them must have been fierce. A review of their late 19th century catalogs (Figs 4A–E[18,19]) reveals they all produced artificial teeth that were "anatomic" in form. For the most part, cusps had a low angle and were blunted. Maxillary and mandibular teeth had distinctive occlusal anatomy. Molars and premolars were properly proportioned, and teeth meant for one side could be differentiated from teeth meant for the other side. Late 19th century developmental efforts seemed to center on esthetics and denture base retention mechanisms,

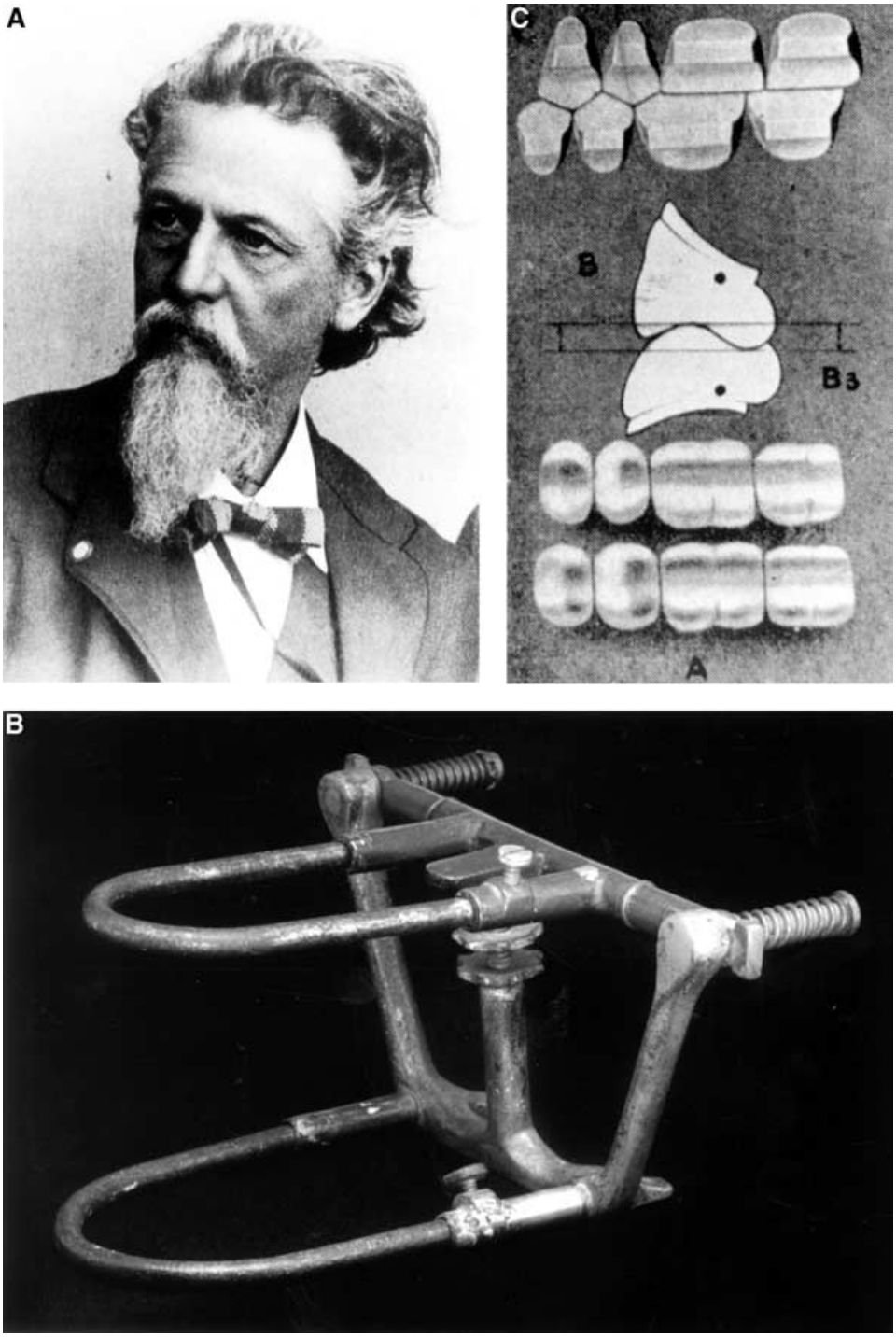

Figure 3. (*A*) W. G. A. Bonwill made numerous contributions to dentistry. Most notable were his articulator (1858) and his geometric theory of occlusion. (*B*) Bonwill's articulator (1858) (from the author's collection). (*C*) Bonwill's method of reshaping posterior denture teeth by grinding anterior–posterior channels in the molars. He did not, however, carry the channels through the bicuspids and so did not clear the occlusion for straight protrusive movements. Sears-chewing members are shown at the top for comparison. (Reprinted from *Journal of Prosthetic Dentistry*, V3, Sears V, Thirty years of non-anatomic teeth, 596-617, Copyright (1953), with permission from The Editorial Council of the *Journal of Prosthetic Dentistry*.)

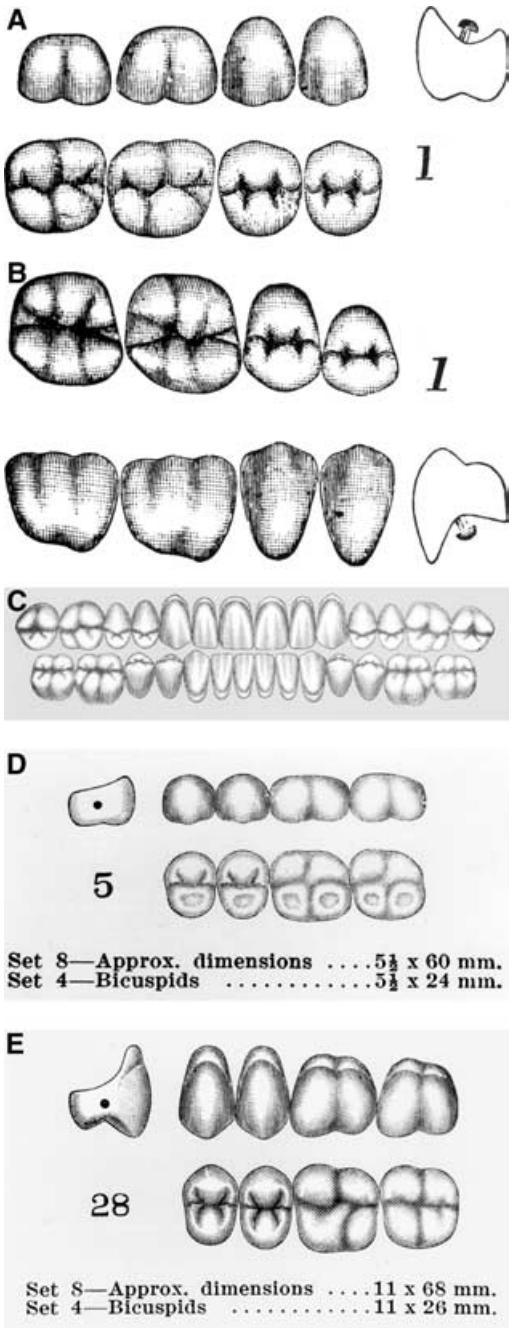

Figure 4. (*A,B*) "Crescent" maxillary (*A*) and mandibular (*B*) posterior porcelain denture teeth patented by Dr. E. A. Floyd (1888—United States; 1889—Great Britain and Canada).[19] (*C*) A complete set of SS White porcelain denture teeth from the turn of the 20th century.[18] (*D*) SS White maxillary porcelain denture teeth with an almost zero cusp angle. The hole on the proximal surface is part of the diatonic design.[18] (*E*) SS White maxillary porcelain denture teeth with cusp angles of approximately 30°. The hole in the proximal surface is part of the diatonic design.[18]

i.e., pin and diatonic design. No evidence could be found in the American catalogues of the late 19th century that any nonanatomic occlusal designs were developed to increase masticatory efficiency, as those by Claudius Ash and Sons above. Instead, it appears that every effort was made by the American producers to create artificial teeth that looked as natural as possible. It was left to the clinicians of the time to alter them to suit the occlusion planned for each individual patient.

References

1. Hoffman-Axthelm W: History of Dentistry. Chicago, Quintessence, 1981, pp 16-286.
2. Craddock FW: A study of artificial posterior teeth. N Z Dent J 1937;33:227-241.
3. Sears V: Thirty years of non-anatomic teeth. J Prosthet Dent 1953;3:596-617.
4. Lang BR, Kelsey CC (eds): International Prosthodontic Workshop on Complete Denture Occlusion. Ann Arbor, U of Michigan School of Dentistry, 1972.
5. Balkwill FH: The best form and arrangement of artificial teeth for mastication. Odont Soc Gt Brit Tr (1st series) 1866;5:133-158.
6. Fereday RC: Francis Balkwill and the philosophy of mastication. Br Dent J 1994;176:86-393.
7. Gysi A: The problem of dental articulators. Br Dent J 1913;34:368-416.
8. Washburn HB: History and evolution of the study of occlusion. Dent Cosmos 1925;4:331-342.
9. Walker WE: Movements of the mandibular condyles and dental articulation. Dent Cosmos 1896;38:573-583.
10. Luce CE: The movements of the lower jaw. Boston Med Surg J 1889;121:8-11.
11. Posselt U: Physiology of Occlusion and Rehabilitation (ed 2). Oxford, Blackwell Scientific Publications, 1968, p 44.
12. Christenson C: The problem of the bite. Dent Cosmos 1905;47:1184-1195.
13. Bennett NG: A contribution to the study of the movements of the mandible. Part III. Proc R Soc Med 1908;1:79-98.
14. Hall RE: Analysis of the work and ideas of investigators and authors of relations and movements of the mandible. J Am Dent Assoc 1929;16:1642-1693.
15. Levin EI: Canine guidance or balancing interference? Dent Pract 1989;27:1-3.
16. D'Amico A: The canine teeth-normal functional relation of the natural teeth of man. J South Calif Dent Assoc 1958;26:200.
17. Bonwill WGA: The scientific articulation of the human teeth as founded on geometrical, mathematical, and mechanical laws—the anatomical articulator. Dent Items Interest 1899;21:617-643, 874-880.
18. Product Catalogue. The Wilmington Dental Mfg. Co., Philadelphia, 1890.
19. World's Premium Teeth (product catalogue). SS White Dental Mfg. Co., Philadelphia, 1915.