ACP
AMERICAN COLLEGE OF PROSTHODONTISTS

Accuracy of a Fixed Value Nasion Relator in Facebow Design

Charles W. Wilcox, DDS, MS[1], James L. Sheets, DDS[1] & Terry M. Wilwerding, DDS, MS[2]

[1] Associate Professor, Department of Prosthodontics, Creighton University School of Dentistry, Omaha, NE
[2] Professor, Department of Prosthodontics, Creighton University School of Dentistry, Omaha, NE

Keywords
Articulator; anterior reference point; orbitale; axis–orbital plane.

Correspondence
Dr. Charles W. Wilcox, Creighton University School of Dentistry, 2500 California Plaza, Omaha, NE 68178. E-mail: ProsMan@creighton.edu

Accepted August 16, 2006

doi: 10.1111/j.1532-849X.2007.00260.x

Abstract

Purpose: This study examined whether a fixed value nasion relator accurately locates the orbitale in a patient population.
Materials and Methods: The mean value for the vertical distance between soft tissue nasion and orbitale was determined through the analysis of cephalometric radiographs of 114 adult patients. This value was then compared to a facebow design, which uses a fixed value of 25.4 mm.
Results: In this study, the mean distance between the orbitale and nasion was found to be 26.8 mm. The values ranged from 15.9 to 39.4 mm with a standard deviation of 3.87 mm.
Conclusion: The difference between the calculated mean and the 25.4 mm fixed value was less than 2.0 mm and presumed to be clinically irrelevant; however, an accumulation of design errors combined with the variation within the patient population was asserted to be clinically relevant and makes the use of a fixed value nasion relator impractical.

Orientation of dental casts within a full-sized articulator is an essential element in producing a realistic laboratory analog of any patient. This process is facilitated by using a facebow to record the orientation of the maxillary arch relative to a patient's cranial base. The maxillary cast is then positioned within the articulator in the same anatomic relation.[1]

The design of the traditional facebow has been attributed to Snow in 1899.[2,3] His facebow included the three elements found in present-day facebows: a bite fork to localize the occlusal plane and placement of the maxillary arch, orientation to the transverse axis between the two condyles, and orientation to an anterior reference plane (the ala-tragus line).[2] Prior to this, maxillary cast placement within an articulator was performed mainly as a matter of mechanical convenience and was arbitrary in nature. Prior to Snow, rudimentary facebows lacked two of the three essential elements, in particular the orientation of the maxillary occlusal plane to the cranial base, as well as orientation to an anterior reference plane. They did not enjoy wide usage.[3,4]

Wadsworth's later addition of the "T" bar to Snow's facebow provided the ". . .first attempt to put into effect a tri-dimensional mounting of casts on an articulator."[4,5] Shaped like a capital "T," the bar's stem rested on one of the condylar indicators, while one side of the crossbar was affixed to the anterior bar of the facebow, aligning the crossbar of the "T" in the vertical plane. The attachment was adjusted until the stem of the "T" bisected the angle between the ala-tragus line and a line from the axis to the outer canthus of the eye. This was called the "naso-optic-condylar triangle" by Wadsworth, and the bisection line was thought to be roughly parallel to the horizon when the patient stood erect.[4] The "T" was also praised for its ability to simplify accurate, reproducible articulator mountings of sequential sets of casts for the same patient.[6]

Subsequent facebow studies centered on the accurate identification of the horizontal axis points,[2,7-10] selection of an appropriate anterior reference point,[2,7-10] and determination of which facial plane most accurately approximated the horizon when the patient stood erect.[2-4,7,9,11-13] Simon has been credited with the first use of an orbital pointer, and the axis–orbital plane became the general standard for cranial base location[11,14] (Fig 1).

In 1956, Stuart patented a simplified articulator he felt would be useful in teaching students. This articulator was successfully marketed by the Whip Mix Corporation (Louisville, KY). It was so successful that Stuart often expressed dismay that his "teaching prop" had become more popular than his later, more capable "gnathologic computer."[6]

For his Whip Mix articulator, Stuart designed a facebow that localized the external auditory meatus (ear pieces) for identification of the hinge axis and used a fixed value nasion relator (25.4 mm) to approximate the position of orbitale. These features were unconventional among facebows of that period, and his rationale for these design choices has not been found. Wilkie concluded that the facebow used an approximate axis–orbital

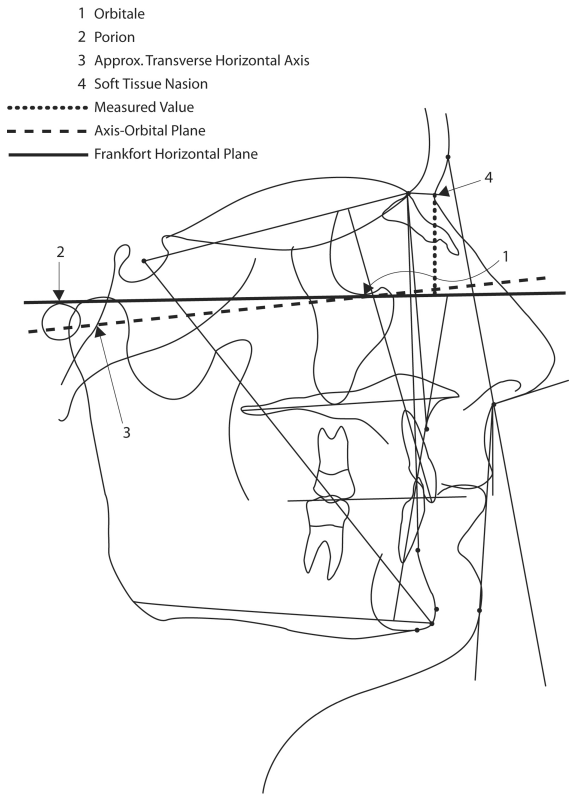

Figure 1 Facebow reference points and planes.

plane.[9] Teteruck and Lundeen found the Whip Mix facebow to be more accurate in its location of the true horizontal axis than two other facebows;[15,16] however, the choice of a fixed value nasion relator to accurately locate orbitale (i.e., the lowest point on the inferior margin of the orbit)[17,18] has been called into question. In clinical usage, the author (CWW) has found that the Whip Mix facebow often produces a mounted maxillary cast that is noticeably misaligned relative to the cranial base, usually with an occlusal plane that is too steep. The purpose of this study was to determine if a fixed value nasion relator accurately located orbitale in a patient population.

Materials and methods

Cephalometric radiographs of 114 patients were analyzed. This group represented all the adult patients seeking orthodontic evaluation at a large, general practice clinic during a 3-year period. Both male and female patients were included, and the patients were all 18 years of age or older. The radiographs were all made with the same cephalometric unit (Ortho-Ralix 9200, Gendex, Lake Zurich, IL) using the manufacturer's specified technique. The same orthodontist made tracings in the usual manner.

The Frankfort Horizontal Plane (FHP), orbitale, and the soft tissue nasion points were identified on a photocopy (Minolta Di20, Shelton, CT) of each cephalometric tracing. Linear measurements were made from orbitale to soft tissue nasion at a 90 angle to the FHP[8,13] (Fig 1).

All measurements were corrected for radiographic distortion (1.08% enlargement) and photocopier distortion (0.98% shrinkage)[19-22]. The resulting data points were rounded to 0.1 mm. Mean and standard deviations were calculated.

Results

The mean distance between orbitale and nasion found in this study was 26.8 mm. The values ranged from 15.9 to 39.4 mm with a standard deviation (σ) of 3.87 mm. The maximum variation from the mean was 12.6 mm (Fig 2).

The fixed value of the Whip Mix nasion relator as measured from the top of the horizontal bar of the facebow and the center of the nasion shaft is 25.4 mm. The center of the nasion shaft was aligned with the greatest convexity of the nasion indicator.

Discussion

The clinical implications for misalignment of maxillary cast occlusal planes include: denture instability,[11-13,23] decreased masticatory efficiency,[11-13,23] damage to supporting tissues,[9] inaccurate sequentially mounted sets of casts,[6,9] and inaccurate orientation of maxillary central incisors vis-à-vis the FHP[9] (i.e., a plane established by the lowest point on the margin of the right or left bony orbit and the highest point on the margin of the right or left bony auditory meatus[1]). Additional clinical implications include: compromise in accurately establishing the anterior angle of disclusion in nonadjustable articulators,[11,13] inaccurate lateral cusp inclines,[10,24] and lack of a common reference plane between mounted casts, clinical examination, and cephalometric radiographs when evaluating and planning orthognathic surgery.[25,26]

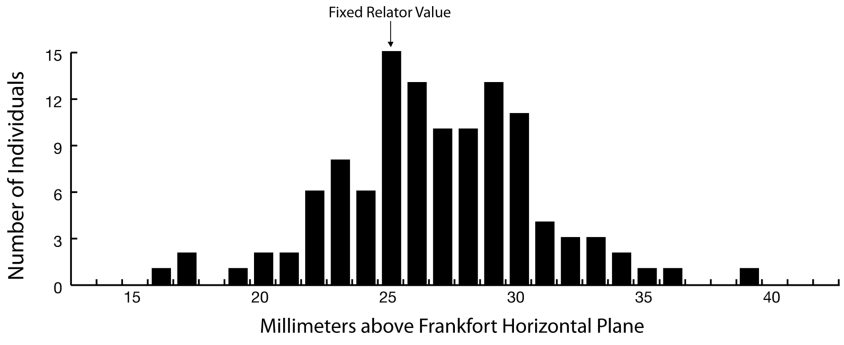

Figure 2 Measured values, FHP to soft tissue nasion.

The most frequently identified reason for this misalignment was inaccuracy in identifying the anterior reference point. A fixed nasion relator length that is too short for a given patient would result in an opposite error in the cast mounting, leaving the anterior point too low, and the occlusal plane too steep.

No absolute limit has been established for acceptable variation in location of the anterior reference point. The clinical relevance of any deviation from the exact location of orbitale is, in the end, dependent upon the demands of the individual clinician and of the procedure for which the maxillary cast mounting is required. With this in mind, the impact of a 2-mm difference ($\simeq 1/2\ \sigma$) is debatable, accounting for the large percentage of patients for whom mounted maxillary casts appear to be normally positioned. This argument gives the impression that the nasion relator's 25.4-mm fixed length is acceptable.

The wide range of variation among patients accounts for a significant change in occlusal plane angulation for those in the extremes of this population. A patient at two standard deviations above the mean (2σ) incurs a 7.75-mm vertical error (39.4 to 26.8 mm) at the maxillary central incisor. As this measurement approximates the length of an average maxillary central incisor, it is asserted that for patients in this scenario, substantial clinical errors would occur. This situation would account for the small, but important, percentage of patients (4.5%, seven individuals in the study population) for whom mounted maxillary casts would appear to be abnormally positioned.

The intended clinical procedure also determines the accuracy required for the articulator mounting of the maxillary cast. A 4-mm vertical change would have little unmanageable effect upon complete denture occlusion, while the same error would have profound implications when planning and executing a Le Fort osteotomy.[25]

Selection of the preferred horizontal plane of reference profoundly affects the nasion-orbitale dimension. Gonzales and others have established that the axis–orbital plane is not parallel to the horizon when the patient stands erect. Rather, it exhibits a positive anterior tilt.[13,22] Gonzales recommended that the orbitale point be moved inferiorly by 7 mm to compensate for this tilt. Pitchford suggested orientation to an "esthetic reference plane" established by leveling the facebow with a bubble level.[12] With this technique, he reported an 18.5-mm difference in anterior reference point vertical position.

Each of the above errors (accuracy of the mean and variation from the mean) when taken alone may seem to be manageable; however, an accumulation of these and the additional errors of technique sensitivity and selection of preferred horizontal plane of reference (where error could exceed 20 mm) condemns the use of a fixed value nasion relator. This is particularly important for procedures where such an error may have profound implications, for example, planning orthognathic surgery.

Erickson et al identified a similar problem in the SAM (SAM Präzisionstechnik GmbH, Gautling [Munich], Germany) articulator.[25] They concluded that the "systematic errors in mounting" caused by a fixed value nasion relator made comparisons between radiographs and mounted casts impossible. This was, in their view, a critical error when planning orthognathic surgical procedures. According to Erickson et al, the SAM facebow has been subsequently modified to include a variable value nasion relator and an orbital pointer that have "largely solved the previous problem."

Conclusions

For this patient population, the mean of the anatomic soft tissue nasion to orbitale distance was within 2 mm of a 25.4-mm fixed value nasion relator, and was judged to be within acceptable clinical tolerances; however, the accumulation of combined errors makes a clinically significant error probable for a significant portion of the patient population. Therefore, a fixed value nasion relator was thought to be impractical. Based on the results of this study, a variable value nasion relator/orbitale indicator is recommended.

References

1. Academy of Prosthodontics: Glossary of prosthodontic terms; GPT-8. J Prosthet Dent 2005;94:12
2. Hall RE: An analysis of the development of the articulator. JADA 1930;17:3-51
3. Brandrup-Wognsen T: The face-bow, its significance and application. J Prosthet Dent 1953;3:618-630
4. Starke EN: The history of articulators: the appearance and early history of facebows. J Prosthodont 2000;9:166-165
5. Contino RM, Stallard H: Oral Rehabilitation and Occlusion, vol 1. San Francisco, CA, University of California School of Dentistry Press, 1958, pp. 64-77
6. Stuart CE, Golden IB: The History of Gnathology. Ventura, CA, CE Stuart Gnathological Instruments, 1981, pp. 116-144
7. Stuart CE: Oral Rehabilitation and Occlusion, vol 5. San Francisco, CA, University of California School of Dentistry Press, 1975, pp. 76-87
8. Beck HO: A clinical evaluation of the arcon concept of articulation. J Prosthet Dent 1959;9:409-421
9. Wilkie ND: The anterior point of reference. J Prosthet Dent 1979;41:488-496
10. Weinberg LA: An evaluation of basic articulators and their concepts: part I, basic concepts. J Prosthet Dent 1963;13:622-644
11. McCollum BB, Stuart CE: A Research Report. Ventura, CA, Chas. E. Stuart, 1955, pp. 54-60
12. Pitchford JH: A reevaluation of the axis-orbital plane and the use of orbitale in a facebow transfer record. J Prosthet Dent 1991;66:349-355
13. Gonzalez JB, Kingery RH: Evaluation of planes of reference for orienting maxillary casts on articulators. JADA 1968;76:329-336
14. Stallard H: Oral Rehabilitation and Occlusion, vol 1. San Francisco, CA, University of California School of Dentistry Press, 1958, pp. 57-63
15. O'Malley AM, Milosevic A: Comparison of three facebow/semi-adjustable articulator systems for planning orthognathic surgery. Brit J Oral Maxfac Surg 2000;38:185-190
16. Teteruck WR, Lundeen HC: The accuracy of an ear face-bow. J Prosthet Dent 1966;16:1089-1046
17. Hwang HS, Kim WS, McNamara JA: A comparative study of two methods of quantifying the soft tissue profile. Angle Orthod 2000;70:200-207
18. Proffit WR, Ackerman JL: Orthodontic diagnosis: the development of a problem list, in: Profit WR (ed): Contemporary Orthodontics (ed 2). St Louis, MO, Mosby, 1993, pp. 163-164

19. Ferrario VF, Sforza C, Miana A, et al: Craniofacial morphometry by photographic evaluations. Am J Orthod Dentofac Orthop 1993;103:327-337
20. Bowley JF, Michaels GC, Lai TW, et al: Reliability of a facebow transfer procedure. J Prosthet Dent 1992;67:491-498
21. Gateno J, Forrest KK, Camp B: A comparison of 3 methods of face-bow transfer recordings: implications for orthognathic surgery. J Oral Maxillofac Surg 2001;59:635-640
22. Pancherz H, Gokbuget K: The reliability of the Frankfort Horizontal in roentgenographic cephalometry. Eur J Orthodont 1996;18:367-372
23. Bailey JO, Nowlin TP: Evaluation of the third point of reference for mounting maxillary casts on the Hanau articulator. J Prosthet Dent 1984;51:199-201
24. Weinberg LA: An evaluation of the face-bow mounting. J Prosthet Dent 1961;11:32-42
25. Erickson KL, Bell WH, Goldsmith DH: Analytical model surgery, in: Bell WH (ed): Modern Practice in Orthognathic and Reconstructive Surgery, vol 1. Philadelphia, PA, Saunders, 1992, pp. 155-163
26. Ellis E, Tharanon W, Gambrell K: Accuracy of face-bow transfer: effect on surgical prediction and postsurgical result. J Oral Maxillofac Surg 1992;50:562-567