UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CLEARCORRECT OPERATING LLC,

Petitioners

v.

ALIGN TECHNOLOGY INC.,
Patent Owner.

IPR2025-00815
U.S. Patent No. 10,524,879

Declaration of Dr. Sumit Yadav
in Support of Petition for *Inter Partes* Review of U.S. Patent No. 10,524,879

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A. Chisthi-511, Chishti-876, Sachdeva, and Becker Render Obvious Claims 1-20 59

1. Independent Claim 1 59

a. [1(pre)] A computer-implemented method comprising: 60

b. [1(a)] determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;.....61

c. [1(b)] calculating, by one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and.....67

d. [1(c)] modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising: 68

e. [1(d)] delaying initial movement of one of the dental objects; and 74

f. [1(e)] round-tripping one of the dental objects. 75

2. Dependent Claim 2: The computer-implemented method of claim 1, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns. 80

3. Dependent Claim 3: The computer-implemented method of claim 1, further comprising recalculating at least one of the respective routes based on the modified schedule of movement. 81

4. Dependent Claim 4: The computer-implemented method of claim 1, further comprising manufacturing at least two

orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages. 82

5. Dependent Claim 5.....84

a. [5(a)] The computer-implemented method of claim 4, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and.....84

b. [5(b)] thermoforming an orthodontic aligner over each respective positive mold.....85

6. Dependent Claim 6.....88

a. [6(a)] The computer-implemented method of claim 1, wherein the round-tripping comprises: moving a first of the dental objects away from the respective route of a second of the dental objects; and 88

b. [6(b)] moving the first dental object toward its respective final position after the second dental object has sufficiently traversed its respective route to avoid the collision.....88

7. Dependent Claim 7.....89

a. [7(a)] The computer-implemented method of claim 1, wherein the round-tripping comprises: moving a first of the dental objects away from the respective route of a second of the dental objects; and 89

b. [7(b)] moving the first dental object toward its previous position.....89

8. Dependent Claim 8.....90

a. [8(a)] The computer-implemented method of claim 1, wherein: the determining of the schedule of movement comprises determining, by one or more computer processors, a total number of the treatment stages; and 90

b. [8(b)] the determining of the total number of the treatment stages comprises: determining, by one or more computer processors, a respective minimum number of treatment stages for each of the dental objects; and 92

c. [8(c)] selecting, by one or more computer processors, a largest of the respective minimum numbers of treatment stages as the total number of the treatment stages. 94

9. Independent Claim 9 97

a. [9(pre)] A non-transitory computer-readable medium comprising instructions that, when executed by one or more computer processors, cause at least one of the one or more computer processors to: 99

b. [9(a)] determine a schedule of movement for dental objects during treatment stages, the dental objects being based from output from a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages; 99

c. [9(b)] calculate a respective route from an initial position toward a desired final position for each of the dental objects during the treatment stages; and.....100

d. [9(c)] modify the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising: 100

e. [9(d)] delaying initial movement of one of the dental objects; and 100

f. [9(e)] round-tripping one of the dental objects. 100

10. Dependent Claim 10: The medium of claim 9, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns. 100

11. Dependent Claim 11: The medium of claim 9, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to recalculate at least one of the respective routes based on the modified schedule of movement. 101

12. Dependent Claim 12: The medium of claim 9, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to control manufacture of at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages. 102

13. Dependent Claim 13: The medium of claim 12, wherein the manufacture comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and thermoforming an orthodontic aligner over each of the respective positive molds. 103

14. Independent Claim 14 103

15. Independent Claim 15 105

a. [15(pre)]-[15(c)]: A computer-implemented method comprising: determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages; calculating, by the one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during

the treatment stages; and modifying, by the one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising.....105

b. [15(d)] determining, by the one or more computer processors, that the respective route of a first of the dental objects results in a collision or obstruction with a second of the dental objects;.....106

c. [15(e)] altering, by the one or more computer processors in response to the determining, the schedule of movement by delaying initial movement of the first dental object;.....107

d. [15(f)] determining, by the one or more computer processors, that the altered schedule of movement still results in a collision or obstruction involving the first dental object; and 108

e. [15(g)] altering, by the one or more computer processors after the determining that the altered schedule of movement still results in a collision or obstruction, the schedule of movement of the first dental object by moving the first dental object out of the path of the second dental object, and once the second dental object has moved sufficiently, moving the first dental object back to the first dental object previous position before proceeding to a desired final position of the first dental object. 111

16. Dependent Claim 16: The computer-implemented method of claim 15, further comprising recalculating at least one of the respective routes based on the modified schedule of movement. 113

17. Dependent Claim 17: The computer-implemented method of claim 15, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic

aligners corresponding to a respective one of the treatment stages. 114

18. Dependent Claim 18: The computer-implemented method of claim 17, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and thermoforming an orthodontic aligner over each of the respective positive molds. 114

19. Independent Claim 19 115

20. Independent Claim 20 116

a. 20(pre)-20(f) 116

b. [20(g)] altering, after the determining that the altered schedule of movement still results in a collision or obstruction, the schedule of movement by round-tripping the first dental object. 118

21. Dependent Claim 21: The medium of claim 20, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns. 119

22. Dependent Claim 22: The medium of claim 20, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to recalculate at least one of the respective routes based on the modified schedule of movement. 120

23. Dependent Claim 23: The medium of claim 20, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to control manufacture of at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages. 120

24. Dependent Claim 24: The medium of claim 23, wherein the manufacture comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and thermoforming a respective one of the orthodontic aligners over each of the respective positive molds. 121

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I. Introduction

1. I, Dr. Sumit Yadav, submit this declaration to state my opinions on the matters described below.

2. I have been retained on behalf of Petitioners ClearCorrect Operating LLC as an independent expert for the above-identified *inter partes* review proceeding involving U.S. Patent No. 10,524,879 (the "'879 patent") (Ex-1001). Although I am being compensated for my time in connection with this IPR at my standard hourly consulting rate of $500 per hour and reimbursed for reasonable out-of-pocket expenses, no part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my technical review, analysis, insights, and opinions regarding the '879 patent, the prior art references that form the basis for the invalidity ground set forth in the Petition for *Inter Partes* Review of the '879 patent, and any other prior art publications cited in this declaration.

II. Qualifications

4. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational and work experience summarized below. My *curriculum vitae* records my education, experience, and publications in greater detail. Ex. 1029.

5. I received a Bachelor of Dental Surgery in 2002 and a Master of Dental Surgery in Orthodontics in 2006, both from India. I received a Ph.D. in Oral Biology from Indiana University – Purdue University, Indianapolis in 2010, and a Clinical Certificate in Orthodontics from University of Connecticut ("UCONN") Health Center in 2013. I am also a Diplomat of the American Board of Orthodontics. In addition, I received my MBA from Northwestern University, Kellogg School of Management, in 2022. My qualifications and experience are also described in my *curriculum vitae* (Ex-1029).

6. I have authored or co-authored more than 140 articles in peer-reviewed journals. These publications span a range of topics, including: clear aligner treatment, orthodontic tooth movement, bone remodeling and modeling, orthodontic anchorage, mini-implant and bone integration, mechanical vibration and orthodontic tooth movement, mechanical vibration and root resorption, mechanical vibration and orthodontic retention, canine impaction, aligner orthodontics, and loading and unloading of the mandibular condylar cartilage of the temporomandibular joint (TMJ). I currently serve on the Editorial Board of Angle Orthodontist, and I am a reviewer for the American Journal of Orthodontics and Dentofacial Orthopedics, The Angle Orthodontist, the European Journal of Orthodontics, PLoS One, Progress in Orthodontics, the Journal of Dental Research, the Journal of Molecular Histology, Tissue Engineering, and the Journal of Applied Oral Science.

7. I have over 22 years of experience as a clinician and 17 years of experience as a research scientist. I am a Professor and Chairman at UNMC College of Dentistry. Since 2012, my research has been funded either through foundation grants (American Association of Orthodontic Foundation and National Institute of Health).

8. I have extensive expertise in orthodontic tooth movement both as a clinician and as a research scientist. I utilize basic biomechanics principles to maximize orthodontic tooth movement with minimal adverse effects in patients. Furthermore, I have worked extensively on optimizing orthodontic tooth movement with Clear Aligner Therapy (CAT) in patients. My research on clear aligners is focused on both the adolescent and adult patients. My research has focused on clear aligners and orthodontic tooth movement (M. Chaluparambil, S. Abu Arqub, C.-L. Kuo, L. Da Cunha Godoy, M. Upadhyay, S. Yadav, *Age-stratified assessment of orthodontic tooth movement outcomes with clear aligners*, Progress in Orthodontics 25:43 (Nov. 2024), https://doi.org/10.1186/s40510-024-00542). In this research, we compared the predicted versus achieved tooth movement between adults and adolescent patients. Our data has shown significant differences between adult and teenagers with CAT. Mandibular central and lateral incisors showed significantly greater over-correction in adults in the horizontal plane. The accuracy of rotations and vertical movements was comparable.

9. I also worked on comparing different aligner systems and their differential effect on orthodontic tooth movement. In this study, we compared treatment efficacy for specific tooth movement between two different clear aligner systems (M.T. Harandi, S. Abu Arqub, E. Warren, C.-L. Kuo, L. Da Cunha Godoy, S. Mehta, J. Feldman, M. Upadhyay, S. Yadav, *Assessment of clear aligner accuracy of 2 clear aligners systems*, American Journal of Orthodontics and Dentofacial Orthopedics, Vol. 164, No. 6, pp. 793-804 (Dec. 2023)). The achieved tooth movement was significantly different than predicted for both aligner systems. We concluded that the efficacy of clear aligner therapy systems in treating mild and moderate malocclusions was comparable. Deviation of the achieved movements from the predicted was greatest for rotational and vertical movements.

10. I have also worked on peripheral nerve regeneration using novel ionically conducting polymers. Nerve defects, particularly those larger than several millimeters, require use of allografts, autografts, or synthetic grafts for nerve regeneration. Allografts/autografts have the limitations of availability, morbidity, and disease transmission. Furthermore, current graft biomaterials are limited in part by slow deterioration of conductivity. We are working on developing a novel ionically conducting polymer that will be electronically stable and will stimulate nerve progenitor cells to heal the nerve defects. Our research has been funded by a UCONN convergence grant to the amount of $50,000.

11. The objective of my National Institute of Health-funded projects is to understand TMJ degeneration and regeneration and to accelerate orthodontic tooth movement. The long-term goal of the applicant (PI) is to understand the mechanism regulating the growth and differentiation of mandibular condylar cartilage (MCC). Temporomandibular joint disorders (TMDs) affect over 15 million Americans, and it is estimated that the United States spends billions of dollars each year on TMDs. Bone Morphogenic Proteins (BMPs) signaling is crucial for the development and postnatal maintenance of MCC, while overexpression of BMP signaling has been associated with degenerative disorders of the cartilage. Despite a wealth of literature on BMPs signaling in the articular cartilage of the knee, little is known about BMPs role in the postnatal growth, adaptive remodeling, and pathogenesis of MCC. In our MCC loading model, we found increased cartilage thickness, increased matrix synthesis and mineralization, as well as increased hypertrophic differentiation of chondrocytes. Moreover, conditional deletion of BMP2 in MCC showed decreased synthesis and mineralization of extracellular matrix and decreased hypertrophic differentiation of chondrocytes. These data suggest that BMP2 regulates MCC growth and differentiation. However, the mechanisms underlying the regulatory effects of BMP2 in the matrix synthesis and hypertrophic differentiation of chondrocytes in MCC remain unknown. Our global hypothesis is that BMP2 is required for postnatal growth and adaptive remodeling of the MCC. Our

understanding is that BMP2 is the master regulator of extracellular matrix synthesis, matrix mineralization, and hypertrophic differentiation of chondrocytes.

III. Materials Considered

12. In forming my opinions, I have reviewed the following documents and any other documents cited in this declaration:

Exhibit No.	Description
Ex-1001	U.S. Patent No. 10,524,879 to Kitching et al. ("'879 patent")
Ex-1002	Prosecution History of U.S. Patent No. 10,534,879
Ex-1004	U.S. Patent No. 6,471,511 to Chishti et al. ("Chishti-511")
Ex-1005	U.S. Patent No. 6,729,876 to Chishti et al. ("Chishti-876")
Ex-1006	Adrian Becker, *The Orthodontic Treatment of Impacted Teeth* (Martin Dunitz Ltd. 1998) ("Becker")
Ex-1007	U.S. Patent No. 6,250,918 to Sachdeva et al. ("Sachdeva")
Ex-1008	*ClearCorrect Operating LLC v. Align, Inc.*, IPR2017-01829, Decision Denying Institution, Paper 10 (PTAB Feb. 5, 2018)
Ex-1009	Speaker Profile of Rohit Sachdeva, retrieved from: https://www.emedevents.com/speaker-profile/rohit-sachdeva
Ex-1010	LinkedIn Profile of Ruedger Rubbert, retrieved from: https://www.linkedin.com/in/ruedger-rubbert-6136b119
Ex-1011	LinkedIn Profile of Ian Kitching, retrieved from: https://www.linkedin.com/in/ian-kitching-3961333
Ex-1012	LinkedIn Profile of Alexander Dmitriev, retrieved from: https://www.linkedin.com/in/alexander-dmitriev-5145991

Exhibit No.	Description
Ex-1013	*Align Technology, Inc. v. ClearCorrect Operating, LLC, et al.*, Case No. 6:24-cv-00187-ADA-DTG, Dkt. 142, Joint Claim Construction Statement (W.D. Tex. Jan. 3, 2025)
Ex-1014	Harold D. Kesling, *The Diagnostic Setup with Consideration of the Third Dimension*, Am. J. Orthodontics, Vol. 42, No. 10, pp. 740-48 (Oct. 1956)
Ex-1015	H.D. Kesling, *Coordinating the Predetermined Pattern and Tooth Positioner with Conventional Treatment*, presented at the meeting of the Southern Society of Orthodontists, pp. 285-93 (Jan. 28-29, 1946)
Ex-1016	Orhan C. Tuncay (ed.), *The Invisalign System* (Quintessence Publishing Co., Ltd. 2006)
Ex-1017	Declaration of Dr. Paul C. Clark
Ex-1018	U.S. Patent No. 6,702,575 to Hilliard
Ex-1019	U.S. Patent No. 6,309,215 to Phan et al.
Ex-1020	Declaration of Kelley M. Hayes Greenhill Regarding Ex-1006
Ex-1021	Declaration of Kelley M. Hayes Greenhill Regarding Ex-1016
Ex-1022	Stanley A. Alexander, *Levels of root resorption associated with continuous arch and sectional arch mechanics*, Am. J. Orthodontics and Dentofacial Orthopedics, Vol. 110, No. 3, pp. 321-24 (Sept. 1996)
Ex-1023	Vincent DeAngelis, *The Amalgamated Technique, a Mechanically and Biologically Efficient Method for Controlled Tooth Movement*, Angle Orthodontist, Vol. 50, No. 1, pp. 1-15 (Jan. 1980)
Ex-1024	Hyo-Sang Park et al., *Group Distal Movement of Teeth Using Microscrew Implant Anchorage*, Angle Orthodontist, Vol. 75, No. 4, pp. 602-09 (2005)

Exhibit No.	Description
Ex-1028	*ClearCorrect Operating, LLC v. Align Technology, Inc.*, IPR2017-01829, Petition for *Inter Partes* Review of U.S. Patent No. 8,038,444, Paper 1 (PTAB July 20, 2017)

IV. Relevant Legal Standards

13. In preparing this declaration and forming my opinions, I am relying on certain legal principles that counsel explained to me. My understanding of these concepts is summarized below.

14. I have been asked to provide my opinions regarding whether claims 1-24 ("the Challenged Claims") of the '879 patent would have been obvious to a person having ordinary skill in the art at the time of the alleged invention, in light of the prior art. I have been advised and understand that prior art includes all analogous art, and that two separate tests define the scope of analogous prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed; and (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved. It is my opinion that the Challenged Claims would have been obvious to a person having ordinary skill in the art at the time of the alleged invention.

15. In forming my opinions expressed below, in addition to my knowledge and experience based upon my work in the fields of computer architecture design, including fault-tolerant computer architecture design, I have considered the documents listed in the Table in Section III above.

16. I have been advised and understand that a dependent claim is a patent claim that refers back to another patent claim. I have been informed and understand that a dependent claim includes all of the limitations of the claim to which it refers.

A. Validity

17. I have been advised and understand that there are two ways in which prior art may render a patent claim unpatentable. First, the prior art can "anticipate" the claim. Second, the prior art can make the claim "obvious" to a person of ordinary skill in the art. I understand that for an invention claimed in a patent to be patentable, it must not be anticipated and must not be obvious based on what was known before the invention was made.

18. I have been advised and understand that a patent claim is unpatentable as anticipated under 35 U.S.C. § 102 if each element of that claim is present either explicitly or inherently in a single prior art reference. I have also been advised and understand that, to be an inherent disclosure, the prior art reference must necessarily disclose the limitation. The fact that the reference might practice or contain a claimed

limitation is insufficient to establish that the reference inherently teaches the limitation.

19. I have been advised and understand that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. I have also been advised and understand that the obviousness analysis takes into account factual inquiries, including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

20. I have further been advised and understand that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include the following: (a) combining prior art elements according to known methods to yield predictable results; (b) simple substitution of one known element for another to obtain predictable results; (c) use of a known technique to improve a similar device (method, or product) in the same way; (d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (e) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and (f) some teaching, suggestion, or motivation

in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

21. When considering the issue of obviousness, I have been advised and understand that I should consider (1) the scope and content of the prior art; (2) the differences between the prior art and the claims at issue; (3) the level of ordinary skill in the art; and (4) evidence of secondary indicia of nonobviousness. I have been informed that secondary indicia of nonobviousness include (i) "long-felt need" for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) "copying" of the claimed invention by others. I have further been advised and understand that in connection with identifying a reason or motivation that would have led a person of ordinary skill in the art (POSITA) to combine or modify the relevant teachings in the prior art to obtain the claimed invention, a POSITA must have had a reasonable expectation of success in doing so. The reason to select and combine features, the predictability of the results of doing so, and a reasonable expectation of success may be found in the teachings of the prior art references themselves, in the nature of any need or problem in the field that was addressed by the patent, in the knowledge of a POSITA at the time, as well as in common sense or the level of creativity exhibited by a POSITA.

B. Level of Ordinary Skill

22. In rendering the opinions set forth in this declaration, I have been asked to consider the ’879 patent’s claims and the prior art through the eyes of a person of ordinary skill in the art. I understand that a person of ordinary skill in the art is determined by considering (1) the type of problems encountered in the art, (2) prior art solutions to those problems, (3) the rapidity with which innovations are made, (4) the sophistication of the technology, and (5) the educational level and years of experience level of those working in the pertinent field.

23. I understand that I must evaluate the ’879 patent from the perspective of a person of ordinary skill in the art. That is, the ’879 patent must be evaluated through the eyes of a person of ordinary skill in the art at the time of the alleged invention of this patent as of its earliest priority date—August 30, 2006. It is my opinion that such a person of ordinary skill in the art as related to the ’879 patent would have been part of an interdisciplinary team. This team would have included members with an advanced degree related to dentistry (e.g., BDS, MDS, DDS, DMD) with experience in orthodontics, including 1-3 years of orthodontic training or equivalent experience, and experience using clear aligners. The team may have also included members with a degree in a technical area related to software, graphics, or computers, or a related discipline. Ex-1017, ¶ 24. This technical team member would have had 1-3 years of experience in software development. Ex-1017, ¶ 24.

For all team member, more education could substitute for work experience and vice versa. Ex-1017, ¶ 24.

24. Based on my educational background and experience, such as my experience with orthodontics (*see* paragraphs 4-11), I am qualified as at least a person of ordinary skill in the art with respect to the ’879 patent. In particular, by August 30, 2006, I had my Bachelor’s in Dental Sciences and Master’s in Dental Sciences in Orthodontics. I had been treating orthodontic patients since October 2003 and had 2-3 years of experience using clear aligners by 2006. To the extent that it is argued that a Doctorate related to dentistry is required to qualify as a POSITA, I also received a Ph.D. in Oral Biology from Indiana University – Purdue University, Indianapolis in 2010. I am also familiar with the knowledge that such a degree holder would have had in 2006, through my further familiarity with research and literature in the field.

25. Thus, I am familiar with the knowledge of the person of ordinary skill in the art at the time of the alleged invention. I am able to opine on how a person of ordinary skill in the art would have understood the disclosure and claims of the ’879 patent, the disclosures of the prior art, the motivation to combine the prior art, and what combinations would have been obvious and not have been obvious to one of ordinary skill in the art.

26. I understand that ClearCorrect previously filed a petition for *inter partes* review against U.S. Patent No. 8,038,444 (the "'444 patent"), which is related to the '879 patent (IPR2017-01829), where ClearCorrect proposed that a person having a doctorate in dental science and three to five years of training and practical experience in orthodontics would qualify as a person having ordinary skill in the art. While I believe such a person would qualify as having at least ordinary skill in the art, it is not my experience that this particular education and experience would be requirements. In my experience, a doctorate in dental science is generally attained by a lower percentage of dentists, and so would be typical of a person with a greater than ordinary skill in the art. In 2006, there were many trained professionals with experience in orthodontics and treatment planning that did not have a doctorate in dental science.

27. For example, it appears that at least two inventors of the '879 patent (Ian Kitching and Alexander Dmitriev) have backgrounds in computer science, but no dental degree. *See* Ex-1011; Ex-1012. Similarly, Sachdeva—a highly relevant prior art reference not previously considered by the Office—includes two inventors: Rohit Sachdeva and Rudger Rubbert. Ex-1007. They exemplify the interdisciplinary team discussed above because Rohit Sachdeva is an orthodontist (*see* Ex-1009), and Rudger Rubbert is an engineer with a background in mechanical engineering (*see* Ex-1010).

C. Claim Construction

28. I have been informed that in an *inter partes* review proceeding, claim terms should be construed under the same standard applied in federal district court cases. Under this standard, I have been informed that claim terms are generally given their ordinary and customary meaning as understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claim terms are generally not limited by the embodiments described in the specification.

29. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I understand that the specification is highly relevant to the claim construction analysis and can be the single best guide to the meaning of a disputed term. I have been informed that the specification acts as a dictionary when it expressly defines terms used in the claims or when it defines terms by implication. I have been informed that this additional evidence is often less significant and less reliable than the claims, specification, and prosecution history.

30. I have been informed that claims should only be construed to the extent necessary to resolve any controversy. For all claim terms, I have considered and applied their plain and ordinary meaning as they would have been understood by one

skilled in the art at the time of the alleged invention and consistent with the specification.

31. I have also been informed that in the parallel district court proceeding, the parties agreed to the meaning below for the following terms:

Claim Term	Construction
round[-]tripping / round-trip ' 879 patent, cls. 1, 6, 7, 9, 20	[moving / move] a first tooth out of the path of a second tooth, and once the second tooth has moved sufficiently, [moving / move] the first tooth back to its previous position before proceeding to a desired final position of that first tooth

32. This construction mirrors Align's definition of "round[-]tripping" recited in the '879 patent's specification and discussed in the grounds presented herein. *See* Ex-1001, 13:9-13.

33. I note that, generally in orthodontics and treatment planning, the term "round-tripping" is a category of tooth movement that can have different implementations. At its highest level, round-tripping is sometimes used to refer to any movement where a tooth moves in a direction other than toward its desired position. Depending on the status of the patient, different implementations of round-tripping can be used to treat the patient. I have applied the '879 patent's definition of round-tripping throughout my analysis.

V. The ’879 Patent

A. Overview of the ’879 Patent

34. The ’879 patent claims priority to August 30, 2006. Ex-1001, p. 2, (60).

35. The ’879 patent describes computerized systems and methods for staging the movement of teeth during an orthodontic treatment. Ex-1001, Title, Abstract, 2:15-17, 8:31-38. The ’879 patent uses a computing device to schedule the movement of teeth from an initial position to a final position, according to various movement patterns and orthodontic techniques. Ex-1001, 2:18-26, 6:18-31, Figs. 2B, 3-9.

36. The system receives a scan of the patient’s teeth in an initial state. Ex-1001, 5:28-32, 5:45-56. Based on this scan, the computer generates a digital model of the patient’s teeth. Ex-1001, 5:48-56. A digital model of the patient’s teeth at a final position is then defined. Ex-1001, 3:59-65, 5:33-35. Using the final position of the patient’s teeth, the computer determines a path of movement for each of the patient’s teeth from initial position to final. Ex-1001, 3:59-4:8, 5:35-44.

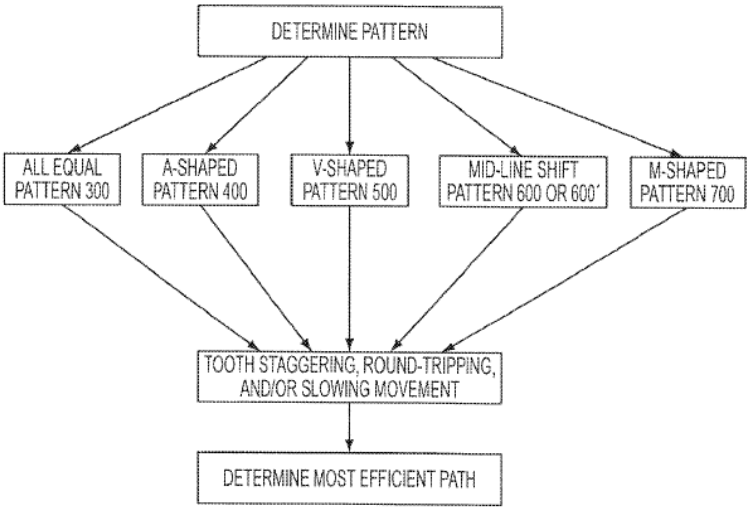


FIG. 2B

Ex-1001, Fig. 2B.

37. As shown above in Figure 2B, one of various patterns of teeth movement is initially selected to be used by the system. Ex-1001, 5:45-48, 5:58-61, 6:64-7:6, 7:66-8:19, 9:37-48, 10:43-52, 12:1-10, Figs. 3-9. For example, Figures 5 and 6B, below, are diagrams depicting the timing of the movement of teeth in a V-shaped and mid-line pattern, respectively. The ’879 patent admits that selecting an orthodontic treatment pattern was disclosed in Chishti-876. Ex-1001, 6:11-17.

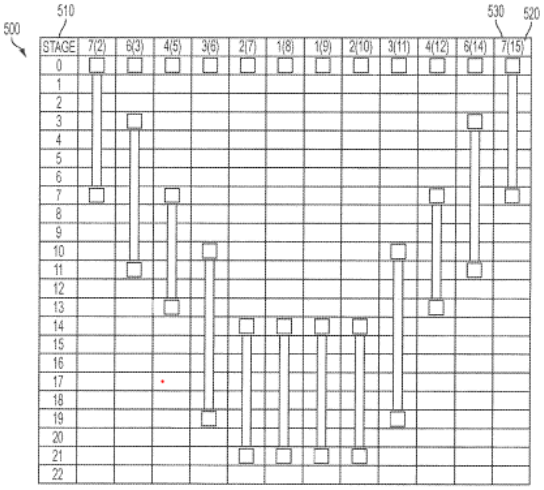


FIG. 5

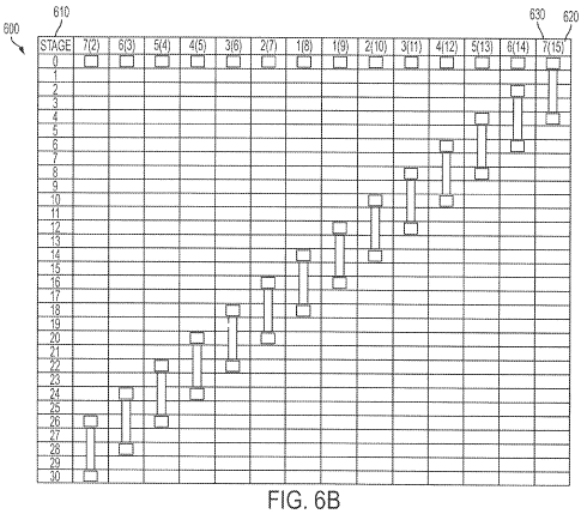


FIG. 6B

V-Shaped Pattern Mid-Line Shift Pattern

38. After selection of the movement pattern, the system determines whether the specified teeth movement would result in collisions between teeth. Ex-1001, 6:44-48. If a collision is detected, the system may modify the treatment plan to include well-known techniques for avoiding collision of the teeth, such as "[s]taggering," "[r]ound-tripping," or "[s]lowing down." Ex-1001, 13:1-13. The '879 patent admits that Chishti-876 discloses techniques for automated computer program determination of whether a collision is likely. Ex-1001, 6:48-55.

39. If a collision is detected, the system automatically modifies the treatment plan by incorporating well-known techniques for avoiding collision of the teeth, such as "[s]taggering," "[s]lowing down," and "[r]ound-tripping." Ex-1001, 12:65-13:13. "Round-tripping" is defined as "the technique of moving a first tooth

out of the path of a second tooth, and once the second tooth has moved sufficiently, moving the first tooth back to its previous position before proceeding to a desired final position of that first tooth." Ex-1001, 13:9-13. The '879 patent states that staggering, slowing down, and/or round-tripping can be applied "alone or in combination, and in any order." Ex-1001, 13:13-15. But in the only exemplary embodiment incorporating all three techniques, the '879 patent describes using staggering first, followed by "slowing-down," and only then using "round-tripping ***as a last resort***." Ex-1001, 13:13-19 (emphasis added).

40. While the '879 patent describes a specific manner of round-tripping, its brief description does not purport to have invented this form (or any form of) round-tripping. Nor does the '879 patent identify any benefits (known or unknown) from this form (or any form) of round-tripping. Instead, as noted above, round-tripping is described in the '879 patent as "a last resort," which indicates that despite the risks associated with it, round-tripping may be a clinically necessary and acceptable technique in some circumstances. Ex-1001, 13:13-19.

B. Prosecution History

41. U.S. Application No. 15/834,649 (the "'649 application") issued as the '879 patent. I understand that during prosecution, the Office initially rejected all claims of the '649 application as anticipated and/or obvious over two publications

to Chishti[1] and one to Phan. In response, Applicant submitted an IDS listing the Board's decision denying institution of IPR2017-01829 (the "'444 IPR") challenging U.S. Patent No. 8,038,444 (the "'444 patent"), a parent of the '649 application, where Chishti references were used. *See* Ex-1002, 203-27. I understand the Board declined to institute *inter partes* review based on, among other things, the definition of "round-tripping" appearing in the specification of the '444 patent, which it determined was not explicitly disclosed in the Chishti references. *See generally* Ex-1008.

42. I understand that while the Examiner maintained certain rejections over Chishti-511 and presented a new ground of rejections in view of Muhammad et al. (U.S. Patent Application Publication No. US 2002/0064746 A1), it noticed as allowable certain claims reciting "round-tripping," further explaining that the allowability of round-tripping was "limited to the definition of [round-tripping] found [in] the specification," i.e., "the technique of moving a first tooth out of the path of a second tooth, and once the second tooth has moved sufficiently, moving the first tooth back to its previous position before proceeding to a desired final position of that first tooth." Ex-1002, 233-34, 223-36.

[1] This includes U.S. Patent Application Publication No. US 2004/0137400 A1 to Chishti et al. and Chishti-511.

43. I also understand that the Applicant amended the independent claims accordingly but still faced a rejection based on informalities in the claim language, double patenting, and inconsistent definitions regarding the "round-tripping" term. Once the informalities were corrected, a terminal disclaimer was filed, and once an Examiner's amendment was approved to ensure "round-tripping" followed the definition set forth in the specification and in IPR2017-01829, the claims were allowed. Ex-1002, 297-298, 368-370.

44. The Office never considered Becker, which discloses the specific type of "round-tripping" defined in the'879 patent.

VI. Overview of the Prior Art

A. Chishti-511 (Ex-1004)

45. I understand that Chishti-511 is a U.S. patent that issued on October 29, 2002, more than one year before the earliest priority date of the '879 patent. Thus, Chishti-511 qualifies as prior art to the '879 patent under at least 35 U.S.C. § 102(b).

46. Chishti-511 is titled "Defining Tooth-Moving Appliances Computationally" and discloses methods and systems for segmenting an orthodontic treatment plan into a sequence of steps. Ex-1004, Title, Abstract. The process involves generating a digital model of the patient's teeth and analyzing the model to define a series of treatment steps to be used with aligners, where the steps

incrementally move the teeth from an initial position towards a final position. Ex-1004, Fig. 1. A high-level outline of this process is shown below:

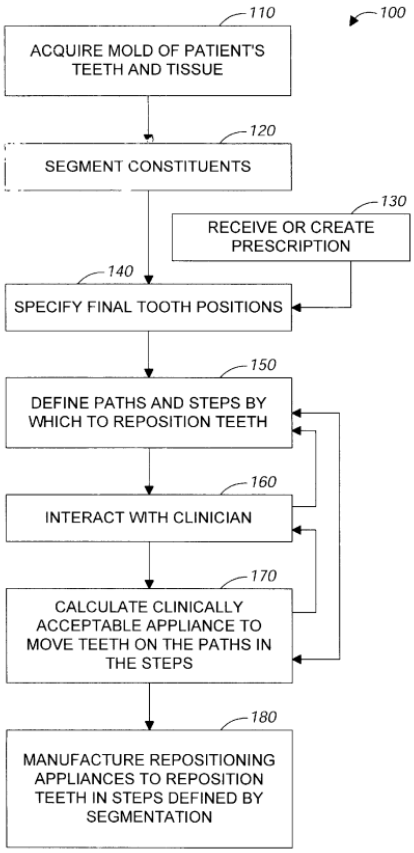


FIG. 1

Id.

47. Chishti-511 explains that after the initial and final positions for each tooth is determined, "the process next defines a tooth path for the motion of each tooth," and that "tooth paths are optimized in the aggregate so that the teeth are moved in the quickest fashion with the least amount of round-tripping to bring the teeth from their initial positions to their desired final positions." Ex-1004, 4:7-12.

Chishti-511 explains that while round-tripping first moves a tooth in a "direction other than directly toward the desired final position," it "is sometimes necessary to allow teeth to move past each other." Ex-1004, 4:13-16.

48. Chishti-511 also discloses that each path segment should "constitute a clinically viable repositioning" such that "moving from one point to the next in the sequence does not result in a collision of teeth." Ex-1004, 4:18-22. After the tooth paths are defined, each path is segmented, and the segmented tooth paths are "used to calculate clinically acceptable appliance configurations (or successive changes in appliance configuration) that will move the teeth on the defined treatment path in the steps specified by the path segments." Ex-1004, 4:51-56. Chishti-511 further discloses that the proposed path for each tooth is compared against certain clinical constraints, and if there is a discrepancy that exceeds a certain threshold, the treatment plan can be modified. Ex-1004, 6:57-62, 7:9-22, 8:22-35. Clinical constraints include, for example, a maximum allowable force on the teeth and acceptable rates of displacement. Ex-1004, 1:59-67, 2:30-40, 6:51-7:8.

49. As shown below, Chishti-511 emphasizes that the process for calculating tooth paths and aligner shapes is an iterative process. Ex-1004, 4:27-50, 5:21-43, 8:42-66, Figs. 1, 2. If the proposed aligner shape does not satisfy the requisite criteria, or changes are made, the subprocess of defining the segmented paths is repeated (*see* "After the treatment path has been redefined, the outer loop of

the overall process is executed again (step **632**)"). Ex-1004, 4:27-35, 8:42-66; Ex-1017, ¶¶ 35-39. This allows for repeated modifications "to redefine those parts of the treatment path having unacceptable aligners." Ex-1004, 8:42-66.

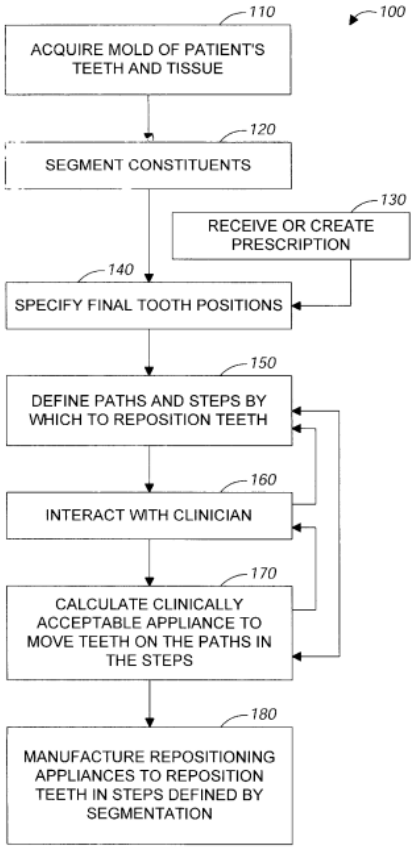


FIG. 1

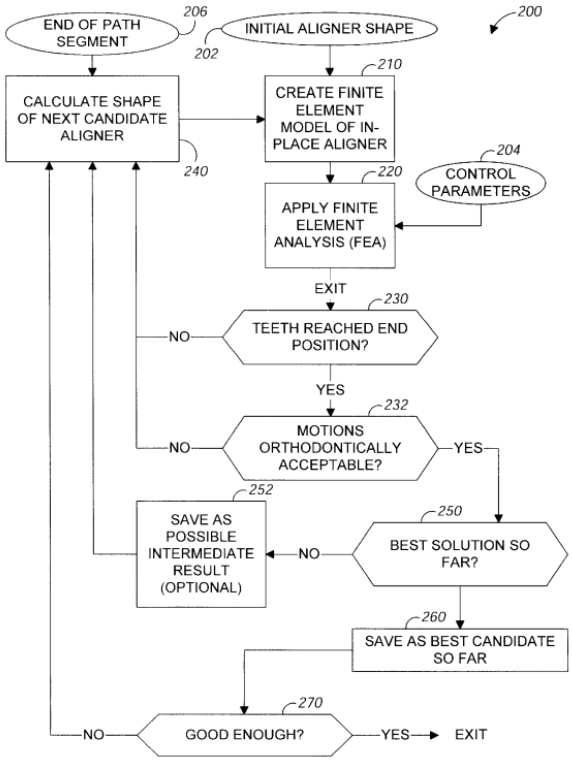


FIG. 2

50. With reference to Figure 1, Chishti-511 explains that "segments are calculated so that each tooth's motion within a segment stays within threshold limits of linear and rotational translation." Ex-1004, 4:15-18. However, after attempting to calculate appliances based on the defined paths, the "limit values can also be updated

based on the result of an appliance-calculation (step 170, described later)." Ex-1004, 4:27-35. And in particular, "[w]ith this information, the subprocess defining segmented paths (step 150) can recalculate the paths or the affected subpaths." *Id.*

51. In calculating the aligners (referring to Figure 2), Chishti-511 explains that the "analysis runs until an exit condition is reached, at which time the process evaluates whether the teeth have reached the desired end position for the current path segment, or a position sufficiently close to the desired end position (step 230)," and "[i]f an acceptable end position is not reached by the teeth, the process calculates a new candidate aligner shape (step 240)." Ex-1004, 5:21-27. Chishti-511 also discloses that a new aligner may be calculated even if an acceptable endpoint is reached, explaining that "[i]f an acceptable end position is reached, the motions of the teeth calculated by the finite elements analysis are evaluated to determine whether they are orthodontically acceptable (step 232). If they are not, the process also proceeds to calculate a new candidate aligner shape (step 240)." Ex-1004, 5:27-32.

52. Additionally, Chishti-511 explains that "[a]ligners may be unacceptable for a variety of reasons." Ex-1004, 8:42-43. And in those circumstances, "the process transfers control to a path definition process (such as step 150, FIG. 1) to redefine those parts of the treatment path having unacceptable aligners (step 630)" if they did not require impossible movements. Ex-1004, 8:54-

58. Chishti-511 further explains that "[t]his step can include both changing the increments of tooth motion, i.e., changing the segmentation, on the treatment path, changing the path followed by one or more teeth in the treatment path, or both." Ex-1004, 8:58-61.

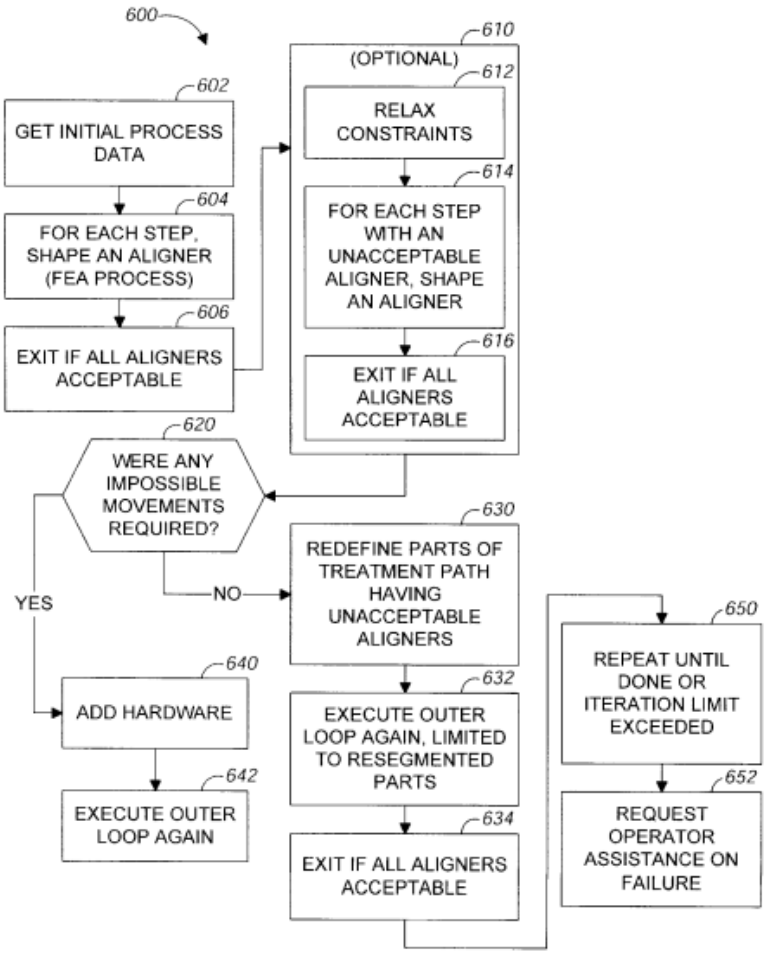


FIG. 6

Id., Fig. 6.

B. Chishti-876 (Ex-1005)

53. I understand that Chishti-876 is a U.S. patent that issued on May 4, 2004, more than one year before the earliest priority date of the ’879 patent. Thus, Chishti-876 qualifies as prior art to the ’879 patent under at least 35 U.S.C. § 102(b).

54. Chishti-876 is titled “Tooth Path Treatment Plan” and discloses systems and methods for preparing a treatment plan that involves selecting a tooth treatment pattern from a library of predetermined movement patterns and implementing the selected pattern in the treatment plan. Ex-1005, Title, Abstract, 2:15-19. Chishti-876 discloses that its algorithm “schedules treatment paths by drawing upon a database of preferred treatments for exemplary tooth arrangements,” and that “[t]his database can be constructed over time by observing various courses of treatment and identifying the treatment plans that prove most successful with each general class of initial tooth arrangements.” Ex-1005, 14:63-15:1. Thus, the database is based on prior successful treatments. The algorithm can “create several alternative paths and present each path graphically to the user.” Ex-1005, 15:1-3.

55. Chishti-876 further discloses the well-known and routine method of manufacturing aligners by thermoforming over a positive mold, where each aligner corresponds to a stage of the treatment plan. Ex-1005, 7:54-64. Chishti-876 also discloses variations in how a tooth may move.

56. Chishti-876 also discloses that "[a] set of rules can be applied to detect any collisions that will occur as the patient's teeth move along the treatment paths" (Ex-1005, 4:11-13), and that "[i]f any collisions are detected, the program alters the path of at least one tooth in each colliding pair by selecting a new position for one of the intermediate steps . . . . The program then samples the new path (**1604**) and again applies the collision detection algorithm (**1606**). The program continues in this manner until no collisions are detected" (Ex-1005, 13:35-45).

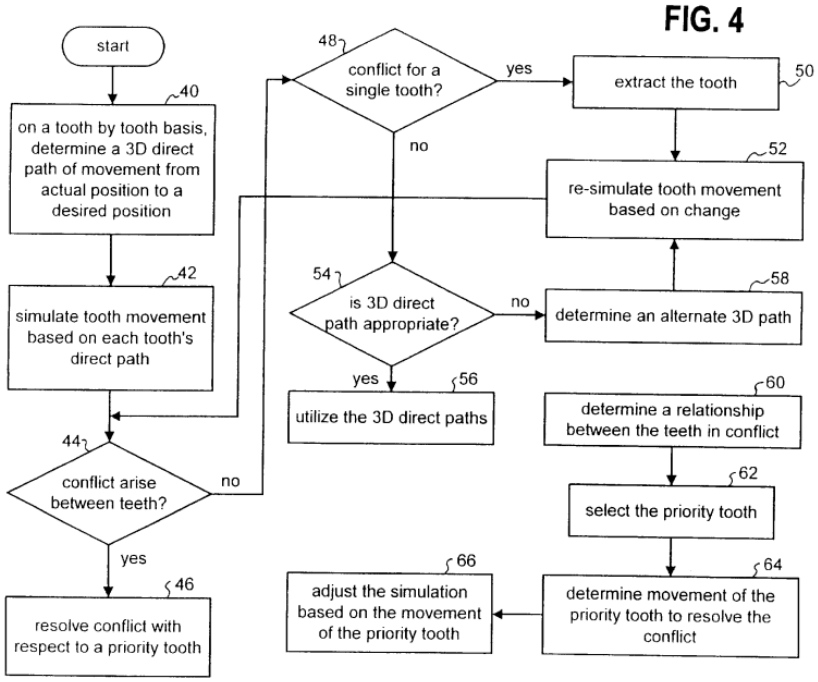
C. Sachdeva (Ex-1007)

57. I understand that Sachdeva is a U.S. patent that issued on June 26, 2001, more than one year before the earliest priority date of the '879 patent. Thus, Sachdeva qualifies as prior art to the '879 patent under at least 35 U.S.C. § 102(b).

58. Sachdeva is titled "Method and Apparatus for Simulating Tooth Movement for an Orthodontic Patient" and discloses using three-dimensional digital models for orthodontic treatment planning. Ex-1007, Title, Abstract, 4:50-5:8. Sachdeva discloses a process that includes comparing a digital representation of a patient's current dental structure with a three-dimensional model of a desired orthodontic structure to determine a three-dimensional direct path of movement. Ex-1007, 3:36-41. Then, the process simulates the tooth movement and determines whether a "conflict" arises between two teeth. Ex-1007, Abstract, 4:50-5:8. Sachdeva explains that a "conflict" arises when "the movement of one tooth

interferes with the direct path movement of another tooth[,] causing a particular tooth to not be able to obtain its desired position." Ex-1007, 5:5-8. If a conflict is detected, it is resolved by modifying the scheduled tooth movement and adjusting the simulation. Ex-1007, 3:43-48, 4:50-5:5, 5:27-32.

59. Sachdeva further discloses a process for resolving a conflict between two teeth that involves delaying one tooth before moving another tooth. For example, "[i]f the lower tooth protrudes preventing the upper tooth from moving back, the lower tooth must be moved before the upper tooth can be positioned. Conversely, if the upper tooth is interfering with the lower tooth from being moved out, the upper tooth must first be moved." Ex-1007, 5:22-26.



Ex-1007, Fig. 4.

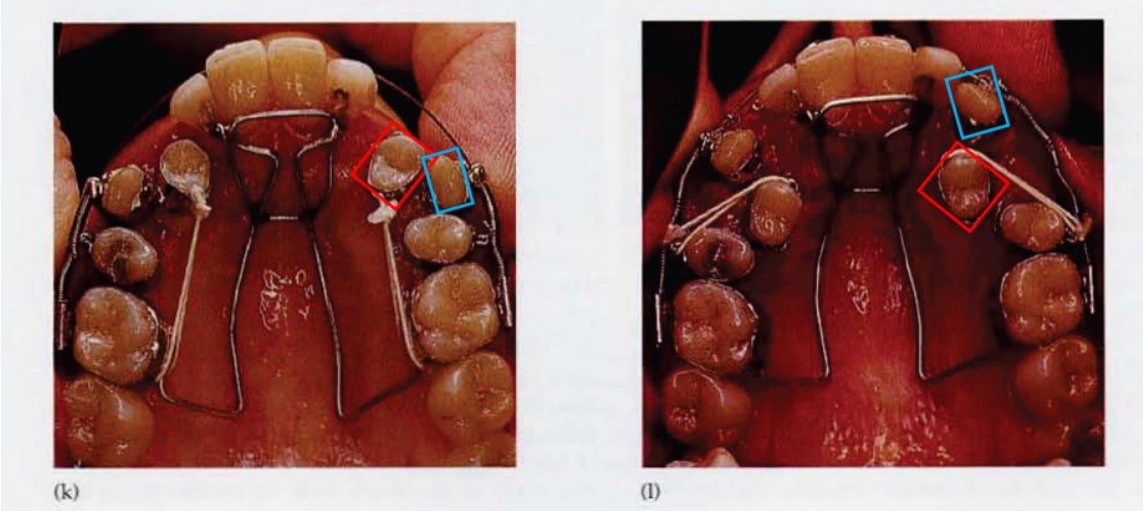
D. Becker (Ex-1006)

60. I understand that Becker is a textbook that published in 1998, more than one year before the earliest priority date of the '879 patent. Ex-1020, ¶¶ 11-20. Thus, Becker qualifies as prior art to the '879 patent under at least 35 U.S.C. § 102(b).

61. Becker is titled *The Orthodontic Treatment of Impacted Teeth* and discloses a method of repositioning a tooth using a round-tripping technique to avoid collisions between teeth. Ex-1006, Title, 5. Becker explains that where a patient's teeth are transposed," the "preferred line of treatment" includes "retranspos[ing] [the teeth] to their ideal position[s]" rather than "align[ing] the teeth in their transposed positions." Ex-1006, 5. In my opinion, a POSITA would have understood that tooth transposition refers to a dental anomaly where a tooth is located in the position normally occupied by a different tooth. In my opinion, a POSITA would have also understood that is often referred to as an ectopic tooth.

62. Becker discloses a method of treatment for this type of malocclusion. Below are before and after images showing a patient, where a more lingual tooth

(i.e., a tooth closer to the tongue in red) is transposed with a more buccal tooth (i.e., a tooth closer to the cheek in blue).[2]



Ex-1006, 7 (Figs. 8.6(k), (l) (annotated)).

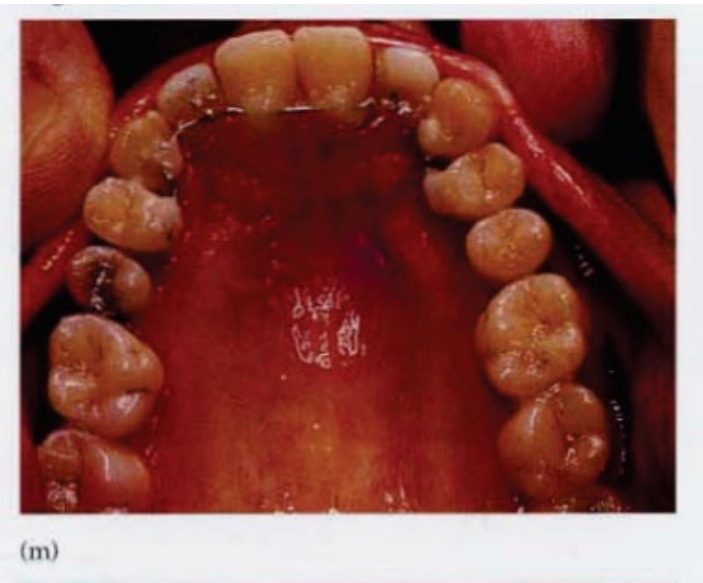
63. The more buccal tooth should be in the position shown on the right, but the lingual tooth is blocking the direct path of the more buccal tooth between its position shown on the right and its position shown on the left. Becker discloses using round-tripping, as described in the '879 patent, to correct the transposition of the

[2] Becker describes the tooth shown in the upper dental arch as a "lingual" tooth and describes movement of that tooth to the center of the mouth as "lingual" movement (i.e., toward the tongue). Ex-1006, 5. But in my opinion, a POSITA would understand that when referencing teeth in the upper arch, movement to the center of the mouth is generally described as "palatal" movement, and that "lingual" movement is used when referencing teeth in the lower arch. I use the "lingual" terminology from Becker in my declaration to describe teeth in the upper arch (and movement thereof), but in my opinion, a POSITA would recognize that Becker's technique applies to teeth in either the upper or lower dental arch (lingual and palatal movement).

teeth. Becker specifically describes "slid[ing]" the more buccal tooth toward the midline (i.e., "in the mesio-distal plane"). Ex-1006, 5. To allow for this, the more lingual tooth "must be moved further lingually" in order "to allow its partner to pass by." Ex-1006, 5. Finally, the more lingual tooth "must be moved ***in the opposite mesio-distal direction and back in the line of the arch***." *Id.* (emphasis added). Becker further explains that "[w]hen moving teeth mesio-distally along an archwire with a multibracketed fixed appliance, the establishment of interproximal contacts between the teeth enables a high degree of control of individual tooth position. Once this has been achieved, uprighting and torqueing movements may be carried out, with care being taken to see that the spaces do not reopen. The desired treatment result includes closed contacts." *Id.*; *see also* Ex-1006, 7 (Figs. 8.6(k), (l)).

64. In my opinion, a POSITA would have understood that Figures 8.6(k) and (l) demonstrate that the more lingual tooth is moved, which allows the more buccal of the transposed teeth to move along the dental arch to the opposite side of the more lingual tooth. Ex-1006, 7 (Figs. 8.6(k), (l)); Ex-1006, 5. The figures also show that after the more buccal tooth has "pass[ed] by," force is applied to the more lingual tooth to move it "in the opposite mesio-distal direction and back in the line of the arch." Ex-1006, 5. In my opinion, a POSITA would have understood that moving the more lingual tooth in the "opposite" direction and "back in the line of the arch" would return the tooth to its previous position, after which the tooth would

proceed toward a desired final position. *Id*. Indeed, Figure 8.6(m) shows the more lingual tooth after it further moved to its final position.



Ex-1006, 8 (Fig. 8.6(m) (annotated)).

E. General Overview of Round-Tripping in the Prior Art

65. Round-tripping—both as a general concept of moving a tooth in a direction other than directly towards its final position, and as the specific type of movement described in the ’879 patent where a tooth moves in one direction and then back to its original position before moving to its final position—was a well-known technique at the time of the invention for avoiding collisions between teeth. Through such indirect movements, clinicians create sufficient space for a second tooth to move towards its final position while avoiding a collision between the two teeth. Round-tripping was understood to be sometimes necessary in cases involving

crowding or impacted teeth, like Becker, where direct movement of either the first tooth or second tooth is not otherwise possible without causing a collision.

66. A clinician presented with a patient where direct movement of a tooth towards its final position is not possible without causing a collision would consider various indirect tooth movement techniques in order to avoid a collision. In my opinion, a POSITA also would have understood that when determining whether to use an indirect movement technique, including round-tripping, to avoid a collision, a clinician would consider both the risks of round-tripping movement (such as root resorption, loss of periodontal support, and prolonged treatment time caused by the round-tripping movement), as well as the benefit of achieving proper alignment while avoiding a collision.

67. Although it was understood that round-tripping should be avoided if possible, it was also understood to be a necessary option for some patients. For example, Chishti-511 explains that moving a tooth in a "direction other than directly toward the desired final position" "***is sometimes necessary*** to allow teeth to move past each other." Ex-1004, 4:9-16 (emphasis added) (describing optimization of tooth paths with the "least amount" of indirect movement). In some instances, the only alternative to round-tripping might be extraction, which could be even less desirable. This is consistent with the '879 patent's disclosure that round-tripping may be used "as a last resort" (Ex-1001, 13:13-19), and with a POSITA's

understanding that while it is preferable to avoid ***unnecessary*** indirect movement techniques, for some patients, some indirect movement may be necessary.

68. Other publications also confirm that round-tripping was well known. As discussed previously, Becker discloses that the "preferred line of treatment" may include the type of round-tripping specifically required in the '879 patent. Ex-1006, 5. Becker discloses that a tooth is moved out of the way for another tooth to "pass by" before it is moved to its previous and then final positions. *Supra* Section VI.D; *infra* Section X.A.1.f. Similarly, Park discloses a known movement technique whereby anterior teeth are moved to a forward position and then "retracted back after creating space with the distal movement of the molars and premolars." Ex-1024, 5-6. DeAngelis also discloses a known movement technique where a tooth is tipped such that the root apex moves "from point *a* to point *b*'," and then is "brought back through point *a* to the desirable end-point *b*." Ex-1023, 2; *see also* Ex-1023, Fig. 1B.

69. Finally, the prior art discloses that some of the reasons clinicians tended to avoid round-tripping may have been based on only anecdotal evidence and were not supported by more rigorous research. *See* Ex-1022, 3 ("It is generally accepted that some level of root resorption will occur in patients undergoing orthodontic treatment. . . . Although many treatment factors have been related to this phenomenon, the presence of 'jiggling' movements or 'round tripping' have anecdotally been stated as a cause for resorption without any hard evidence.");

Ex-1022, 1 ("Both treatment groups exhibited the same levels of resorption indicating that the side effect of treatment may be due to individual variation and not to the 'round tripping' of teeth so often assumed.").

70. In short, the '879 patent's discussion regarding round-tripping is neither novel nor nonobvious but rather reflects a widespread consensus at the time of the '879 patent that round-tripping was an option to be considered, with advantages and disadvantages, and that round-tripping would be used as necessary if it was the best (or potentially only) available treatment option.

VII. Analogous Art

71. In my opinion, each of Chishti-511, Chishti-876, Sachdeva, and Becker is analogous art to the '879 patent and to each other. The '879 patent states that the "present invention is related generally to the field of orthodontics, and more particularly to staging a path of movement for correcting the position of one or more teeth." Ex-1001, 1:23-25. Like the '879 patent, each of Chishti-511, Chishti-876, Sachdeva, and Becker is in the same field of endeavor, as each is directed to orthodontic treatment for repositioning misaligned teeth in patients. *See* Ex-1004, Abstract (discussing "orthodontic treatment path into clinically appropriate substeps for repositioning the teeth of a patient"); Ex-1005, Abstract ("prepar[ing] a malocclusion treatment plan"); Ex-1007, Abstract (discussing that "simulating tooth movement for an orthodontic patient include[s] processing that begins by

determining, on a tooth by tooth basis, a three-dimensional direct path of movement"); Ex-1006, 5 (discussing movement of teeth).

72. In my opinion, Chishti-511, Chishti-876, Sachdeva, and Becker are also analogous art because they are reasonably pertinent to the problem that the '879 patent purports to solve. In particular, the '879 patent discusses planning a path for correcting the position of teeth and addressing the problem of avoiding potential collisions of teeth along that path. Ex-1001, 1:23-25, 6:44-55 (the system "is configured to determine[] if the pattern should be modified to accommodate the teeth movement of the current patient to avoid collision"), 6:56-63 (discussing methods of avoiding collisions).

73. Chishti-511, Chishti-876, Sachdeva, and Becker are reasonably pertinent to this same problem. Chishti-511 discloses "defin[ing] a tooth path for the motion of each tooth" (Ex-1004, 4:7-9), and Sachdeva discloses making "a determination . . . as to whether a conflict in movement" would arise as the teeth move (Ex-1007, 5:3-8). Chishti-876 similarly relates to generating a "malocclusion treatment plan," which includes "determining a tooth path [which] includes finding a collision[-]free shortest path." Ex-1005, 2:21-30. To help accomplish that goal, Chishti-876 discloses the use of "treatment pattern[s]" that "can be selected from one or more clinical treatment prescriptions." *Id.* Sachdeva similarly discloses "determining, on a tooth by tooth basis, a three-dimensional direct path of

movement" as well as "determin[ing] whether a conflict arises between at least two teeth" and resolving that conflict. Ex-1007, Abstract. Finally, Becker shows a known round-tripping technique used in a patient's orthodontic treatment and demonstrates how to avoid potential collision of teeth using that technique. Ex-1006, 5.

VIII. Motivation to Combine

74. In my opinion, a POSITA would have been motivated to combine the Ground 1 references with a reasonable expectation of success.

75. In my opinion, a POSITA would have been motivated to use Sachdeva's and Becker's collision identification and avoidance techniques to supplement Chishti-511's treatment planning system. Chishti-511 already discloses that its system is intended to result in "a clinically viable sequence of tooth positions." Ex-1004, 4:15-22. Chishti-511 further recognizes that, to accomplish a clinically viable sequence, its system must achieve a treatment such that "moving from one point to the next in the sequence does not result in a collision of teeth." Ex-1004, 4:18-22. In light of this express disclosure, in my opinion, a POSITA would have been motivated to look to teachings regarding the identification and avoidance of collisions.

76. Sachdeva provides such a teaching. Like Chishti-511, Sachdeva recognizes that collisions are undesirable. *See* Ex-1007, 5:5-8 ("A conflict may arise in that the movement of one tooth interferes with the direct path movement of

another tooth[,] causing a particular tooth to not be able to obtain its desired position."). Sachdeva further teaches a process for identifying collisions as well as methods for resolving them. *See* Ex-1007, 5:3-26, Fig. 4. For example, Sachdeva discloses an automated process for resolving a conflict by giving one tooth priority to move it before another tooth (delaying one tooth), and it further explains how the changes will cause adjustments in the simulated treatment. Ex-1007, 5:3-32.

77. In my opinion, a POSITA would have recognized that integrating Sachdeva's automated collision identification, avoidance, and adjustments features into Chishti-511 would provide implementation details for the features disclosed in Chishti-511 and would help achieve the "clinically viable sequence of tooth positions" sought by Chishti-511—that is, helping prevent the undesirable result of producing a set of aligners that will cause a collision. Indeed, in my opinion, a POSITA would have understood that the type of collision avoidance disclosed by Sachdeva (delaying an initial movement of a tooth) was a well-known treatment technique at the time of the invention. *See, e.g.*, Ex-1014, 6, Howard D. Kesling, *The Diagnostic Setup with Consideration of the Third Dimension* (describing a scenario wherein a patient's canine teeth are repositioned after "the central and lateral incisors are repositioned, and are in proper axial inclination," and another scenario wherein a second premolar tooth is repositioned after extracting a first premolar to create space); Ex-1015, 5, H.D. Kesling, *Coordinating the Predetermined Pattern and*

Tooth Positioner with Conventional Treatment ("Treatment of both arches can be carried on together, bearing in mind that the mandibular teeth should advance toward the predetermined pattern and stationary anchorage somewhat ahead of the maxillary teeth."); Ex-1016, 124 & Fig. 12-10a (describing a "[h]igh-anchorage pattern" used when "crowding on the anterior teeth requires that the space is created by the distal movement of the posterior teeth," where the anterior teeth are only moved after the posterior teeth have moved)[3]. In my opinion, a POSITA would have understood that such a system would improve patient results by avoiding unacceptable collisions and increase efficiency by reducing the need for a clinician to manually identify collisions.

78. I understand, a POSITA would have had a reasonable expectation of success in combining Chishti-511 with Sachdeva's collision identification and avoidance features. Ex-1017 ¶¶ 55-61. Indeed, Chishti-511 teaches that new candidate aligners will be calculated in various circumstances, such if "the motions of the teeth" are not determined to be "orthodontically acceptable" or an "an acceptable end position is not reached by the teeth." Ex-1004, 5:27-32 ("If an acceptable end position is not reached by the teeth, the process calculates a new candidate aligner shape (step **240**). If an acceptable end position is reached, the

[3] I understand that Tuncay (Ex-1016) was publicly available at least by August 17, 2006. Ex-1021, ¶¶ 21-37.

motions of the teeth calculated by the finite elements analysis are evaluated to determine whether they are orthodontically acceptable (step 232). If they are not, the process also proceeds to calculate a new candidate aligner shape (step 240).”). A POSITA would understand that a collision between teeth is not “orthodontically acceptable” and would recognize that teeth are unlikely to reach their endpoint in the event of a collision. A POSITA would thus recognize the applicability of Sachdeva’s collision-related features to Chishti-511’s system for determining the acceptability of aligners (e.g., triggering whether a new aligner should be calculated). *See also* Ex-1004, 8:22-65, 4:7-22; Ex-1007, 5:3-32. I understand such a combination would have required little more than software modifications, and a POSITA would have had a reasonable expectation of success in combining these teachings. Ex-1017 ¶¶ 55-61.

79. In my opinion, a POSITA similarly would have been motivated to combine Chishti-511 with Becker’s teachings regarding round-tripping. As discussed above, Chishti-511 already discusses the need to have collision-free treatment paths (Ex-1004, 4:15-22), and thus, a POSITA would have been motivated to look to techniques for avoiding collisions during treatment. In my opinion, a POSITA would have recognized that different patients may require different treatments, and thus would have been motivated to include multiple treatment methods to avoid potential collisions. For example, Becker provides one such

teaching, illustrating how round-tripping—as specifically discussed in the '879 patent—can be used to avoid collisions in the case of transposed teeth. Ex-1006, 5-7. For example, in transposition cases involving canines, a POSITA would have understood that a treatment plan might include repositioning the canine to its proper position, and that for some patients, round-tripping might be preferable over a different treatment (e.g., extracting the tooth) because canine teeth play a critical role in preventing collapse of the dental arch.

80. While the treatment shown for Becker's patient is one example, a POSITA would have understood that, depending on the specifics of a patient's malocclusion, there are different ways to implement the concept of round-tripping, such as that disclosed in Becker. For example, a POSITA would have understood, that after the first tooth has been moved to its previous position, the first tooth would be free to move to a different, desired final position, depending on the needs of the patient. Similarly, a POSITA would have also understood that if only minor tooth movement is required to avoid collision with a path of a second tooth, aligners alone may be used to move the first tooth out of the path of a second tooth sufficiently to avoid a collision and then moving the first tooth back to its previous position before moving it towards its final position. In that case, depending on the initial malocclusion of the patient, the "first tooth" may not need to move as far to be "out of the path" of the second tooth to avoid a collision. *Id.*

81. A POSITA would also recognize that in other cases, treatment where more significant tooth movement is needed to avoid a collision may utilize aligners with attachments, such as attachments shown in Becker, to achieve the desired movement. In my opinion, a POSITA would understand that use of such attachments was well known in the art at the time of the invention. For example, Chishti-511 describes that its process for computing the shape of an aligner will also take into account hardware attachments if necessary to create the tooth motion. *See* Ex-1004, 8:47-53 ("process 600 proceeds to execute a module that calculates the configuration of a hardware attachment to the subject tooth to which forces can be applied to effect the required motion"). Similarly, when discussing manufacturing of its aligners, Chishti-511 recognize that this will account for "the position and selection of attachments, and the addition or removal of material (e.g., adding wires or creating dimples) to change the structure of the aligner." *Id.*, 10:1-6; *see also id.*, 6:21-24. State of the art confirms that use of attachments, as shown in Becker, with aligners were well known at the time of the invention. For example, it was known that attachments may be used with Essix aligners to accomplish various types of movement, including labial and lingual movement, lateral movement, torque, rotation, and to adjust arch relationships. *See* Ex-1016, 26, 30-38. As one example, a button could be constructed on the aligner to which an elastic may be attached. Ex-1016, 34, 35 (Fig. 2-24c). Alternatively, a "facial window" may be cut into the clear

aligner in the area where a button is bonded to the surface for a tooth, where the button serves as "the base for [an] elastic vector." Ex-1016, 37; *see also* Ex-1018, Abstract, 11:45-65; Ex-1019, Abstract, 3:21-48. Thus, a POSITA would have understood that depending on the type of malocclusion, aligners may be used either alone or with attachments to achieve the type of round-tripping disclosed in Becker.

82. Although round-tripping can have disadvantages, a POSITA would have recognized that for some patients, there may be no other option other than to round-trip one or more teeth, particularly if the patient or clinician wishes to avoid extracting one or more teeth. Indeed, Chishti-511 expressly discloses that round-tripping—understood more broadly as any motion of a tooth in any direction other than directly toward the desired final position—"is sometimes necessary to allow teeth to move past each other." Ex-1004, 4:13-15. Chishti-511, Becker, and the '879 patent are thus all consistent in understanding that round-tripping—whether understood more broadly or as specifically defined in the '879 patent—may be required to treat certain patients, even if it is, in the words of the '879 patent, "a last resort." Ex-1004, 4:9-12; Ex-1001, 13:13-19. Accordingly, a POSITA would have been motivated to include round-tripping as one feature in a system with robust software for generating treatment plans for a broad range of different patients with different needs. Adding a well-known feature such as round-tripping to make Chishti-511's treatment planning software more robust thus would have been

obvious, even if those features are only used in rare cases or as a last resort for patients that might otherwise not be able to be treated.

83. Moreover, I also understand that a POSITA would have had a reasonable expectation of success in combining these teachings. Ex-1017 ¶ 62. Like Sachdeva's technique, a POSITA would have been motivated to integrate Becker's round-tripping technique as an option in Chishti-511's algorithm for calculating new aligners, such as when it is determined that the aligner is unacceptable (e.g., the treatment plan results in a collision). Ex-1004, 5:25-32, 8:42-61, Fig. 6; Ex-1017, ¶62. If a collision is detected, the combined system would have Becker's technique as an option for use in Chishti-511's path redefinition process, which already incorporates other types of changes to tooth movement, to resolve the collision. I understand that adding the option to use Becker's technique to round-trip one or more teeth as part of generating a treatment plan would have involved a software modification related to Chishti-511's algorithm for calculating new aligners (similar to that discussed for Sachdeva), which would have yielded predictable results and had a reasonable expectation of success. Ex-1017, ¶ 62. To the extent that it is argued that the prior art teaches away from the proposed combination, I disagree because the prior art discloses at least as much as the '879 patent itself for the round-tripping limitation. While Chishti-511 says teeth should be moved "with the least amount of round-tripping," (Ex-1004, 4:9-11), Chishti-511 describes round-tripping in the

same manner as the ’879 patent. Chishti-511 teaches that “[r]ound tripping is sometimes necessary to allow teeth to move past each other” *Id.*, 4:13-15. Chishti-511 recognizes there may be some disadvantages of round-tripping and recommends avoiding such movement when possible, but it also recognizes that round-tripping may be necessary in some circumstances. Ex 1004, 4:9-16. This is analogous to the ’879 patent’s disclosure, which refers to round-tripping as a matter of “last resort” when the collision cannot be resolved by other collision avoidance techniques. Ex-1001, 13:1-19.

84. In my opinion, a POSITA also would have been motivated to combine Chishti-876’s teachings regarding the use of movement patterns and the generation of schedules of movement with Chishti-511’s treatment planning system. Chishti-511 already discloses the importance of tailoring the generated treatment plan according to a clinician’s preferences and of proposing treatment plans for a clinician’s approval, and the use of predetermined movement patterns would facilitate interactions with a clinician by providing repeatable, known treatment techniques. *See, e.g.*, Ex-1004, 3:59-64 (discussing receiving prescription and constraints from clinicians and allowing clinician interaction through a client), 2:45-53, 4:36-50. A POSITA would have understood that such a modification would improve efficiency by allowing a technician to generate a treatment plan more quickly. It would also improve treatment quality by applying treatment techniques

that had been used successfully for similar patients, implement clinician preferences, and improve patient flexibility by providing the type of treatment appropriate for each patient's needs. It would also potentially decrease the number of requested modification or refinements necessary to achieve the desired result. I also understand that a POSITA would have had a reasonable expectation of success in combining Chishti-876's selection of a plurality of patterns in Chishti-511's system. Ex-1017, ¶¶ 63-64.

85. It is also my opinion that, a POSITA also would have been motivated to combine Chishti-876's teachings regarding a schedule of movement indicating whether each dental object moves during each of the treatment stages and the calculation of the total number of treatment stages and minimum stages for each tooth with Chishti-511, as these modifications would provide transparency and predictability to the patient and clinician, as well as improve treatment efficiency. Chishti-511 already discloses calculating the movement of each dental object over the treatment plan to ensure that each complies with orthodontically acceptable thresholds, and it further discloses calculating the steps of the treatment plan to accomplish the necessary repositioning in the quickest fashion. *See, e.g.*, Ex-1004, 4:15-22 (explaining that the system calculates a segmented treatment plan), 4:7-12 (explaining that tooth paths are optimized "so that the teeth are moved in the quickest fashion"). A POSITA would thus have been motivated to look to Chishti-876, which

explains that the system determines whether teeth move or to not move during each discrete stage of the treatment plan (Ex-1005, 10:11-18), and further determines the total number of treatment stages in the plan by calculating the number of stages for the final tooth to reach its desired final position, and determines the minimum stages for each tooth by finding the "shortest" path. Ex-1005, 11:26-40, 17:1-16, Figs. 11-13, Claim 3. Such a change would be beneficial, as it would allow both patients and clinicians to understand whether/when teeth would move during the treatment, as well as how many stages would be required for each tooth (determining the number of stages). Determining the minimum number of stages for each tooth would also benefit the system, as it would allow it to compare treatments to see which is "quickest." Ex-1004, 4:7-12. I also understand a POSITA would have had a reasonable expectation of success in making such a change. Ex-1017, ¶¶ 74-76.

86. For the various features of Chishti-876, Sachdeva, and Becker discussed in this declaration, in my opinion those various features would not have interfered with one another when combined with Chishti-511's system. *See also* Ex-1017, ¶ 79.

IX. Ground of Unpatentability

87. Based on my review of the materials set forth above, including my application of the knowledge of a person of ordinary skill in the art, it is my opinion that the Challenged Claims of the '879 patent would have been obvious to one of

ordinary skill in the art at the time of the purported invention (August 30, 2006). In particular, it is my opinion that the Challenged Claims of the ’879 patent would have been obvious to one of ordinary skill in the art based on the ground shown below:

Ground	Claims Challenged	35 U.S.C.	References
1	1-24	§ 103	Chisthi-511, Chishti-876, Sachdeva, and Becker

X. Claims 1-24 of the ’879 Patent Are Unpatentable

88. In my opinion, claims 1-24 of the ’879 patent would have been obvious based on the teachings of Chisthi-511, Chishti-876, Sachdeva, and Becker for the reasons I have provided below in the asserted ground of unpatentability.

A. Chisthi-511, Chishti-876, Sachdeva, and Becker Render Obvious Claims 1-20

89. In my opinion, Chishti-511 in view of Chishti-876, Sachdeva, and Becker renders obvious claims 1-24.

1. Independent Claim 1

90. In my opinion, Chishti-511 in view of Chishti-876, Sachdeva, and Becker discloses or renders obvious each limitation of claim 1.

a. [1(pre)] A computer-implemented method comprising:

91. In my opinion, to the extent the preamble is limiting, Chishti-511 discloses a computer-processor-implemented method for orthodontic treatment planning. Ex-1004, Abstract (providing for "[m]ethods and corresponding apparatus for segmenting an orthodontic treatment path into clinically appropriate substeps for repositioning the teeth of patient"); *see also* Ex-1004, 10:19-51, 1:33-39, 2:34-39.

92. Chishti-511 explains that the "data processing aspects of the invention can be implemented advantageously in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from and to transmit data and instructions to a data storage system, at least one input device, and at least one output device." Ex-1004, 10:29-35. In my opinion, this is consistent with Chishti-876's and Sachdeva's disclosures of one or more computer processors for executing instructions to perform its relevant steps. *See* Ex-1005, 13:23-48, 23:7-32; Ex-1007, 4:39-49. Chishti-876 and Sachdeva similarly disclose one or more computer processors for executing instructions to perform their relevant steps. *See* Ex-1005, 13:23-48, 23:7-32; Ex-1007, 4:39-49. Thus, subsequent limitations requiring performance "by one or more computer processors" are met by Chishti-511, Chishti-876, and Sachdeva.

b. [1(a)] determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;

93. In my opinion, Chishti-511 alone or in view of Chishti-876 renders obvious this limitation. Chishti-511 discloses dental objects being based from output of a scanning device. Chishti-511 gathers data by acquiring "a mold ***or a scan*** of [a] patient's teeth" in order to create "a digital data set" representative of the patient's initial arrangement of dental objects. Ex-1004, 3:40-50 (emphasis added); *see also* Ex-1004, 3:51-58.

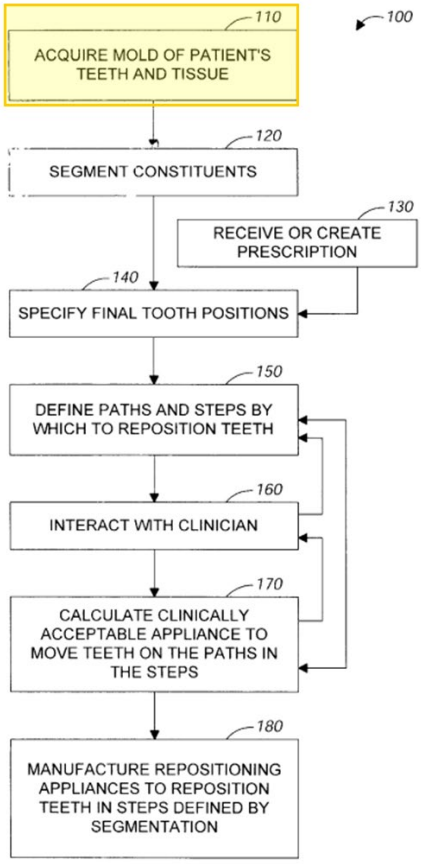


FIG. 1

Ex-1004, Fig. 1 (annotated).

94. Chishti-511 further discloses determining a schedule of movement for dental objects during treatment stages. In particular, Chishti-511 discloses that the system will receive the "desired final position of the teeth." Ex-1004, 3:59-4:6. For example, Chisthi-511 discloses that the "desired final position of the teeth" can be "calculated from basic orthodontic principles" or "extrapolated computationally from a clinical prescription" received from a clinician. *Id.* Once the beginning and final positions are established for each tooth, the process "defines a tooth path for

the motion of each tooth." Ex-1004, 4:7-22. The teeth are moved along this tooth path toward the desired final tooth positions without exceeding safety or discomfort thresholds. *Id.* To achieve this, "[t]he tooth paths are segmented" such that the "end points of each path segment" represent a "clinically viable repositioning," and "the aggregate of segment endpoints constitute[s] a clinically viable sequence of tooth positions." *Id.*

95. The segmented tooth paths are then "used to calculate clinically acceptable appliance configurations . . . that will move the teeth on the defined treatment path in the steps specified by the path segments." Ex-1004, 4:51-67. A POSITA would have understood that the sequence of tooth positions and corresponding appliance configurations is a schedule of movement that indicates whether a dental object moves during each of the treatment stages.

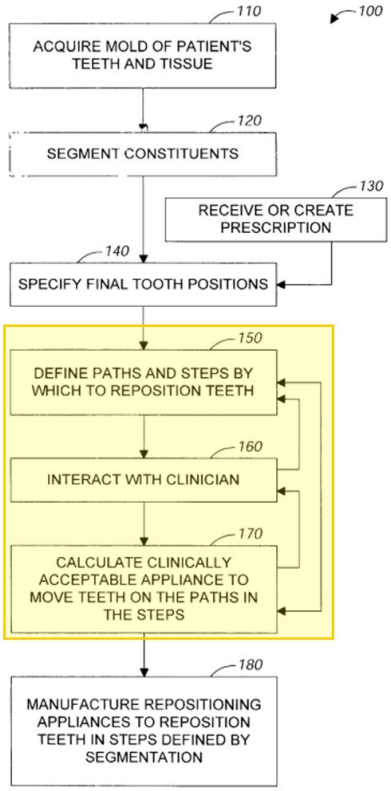


FIG. 1

Ex-1004, Fig. 1 (annotated).

96. In my opinion, a POSITA would have understood that the segmented schedule of movement will indicate whether a dental object moves during that treatment stage. Indeed, a POSITA would have understood that each dental object may not necessarily need to move during each treatment stage to reach its final position, as some dental objects may reach their respective final position before others. Additionally, Chishti-511 indicates that some teeth will not move at all, which will be reflected in the schedule of movement. *See*, *e.g.*, Ex-1004, 6:63-66

("Having received the initial input data (step 420), the process iterates over the movable teeth in the model. (Some of the teeth may be identified as, and constrained to be, immobile.)").

97. Moreover, to the extent it is argued that this feature is not fully disclosed by Chishti-511, Chishti-876 discloses and renders obvious this feature. For the reasons explained in Section VIII, a POSITA would have been motivated to modify Chishti-511 to include Chishti-876's teachings regarding a schedule of movement indicating whether each dental object moves during each of the treatment stages. Chishti-876 discloses that its system will "define or map the movement of selected individual teeth from the initial position to the final position over a series of successive steps." Ex-1005, 9:13-20; *see also* Ex-1005, 7:13-19, Fig. 3. Chishti-876's system "takes into consideration" "[m]ovement: a detailed, sequential description of how the patient's teeth should be moved in order to accomplish the desired goals for final placement," which is a section of the treatment plan that "specifies an order [of] moving the patient's teeth." Ex-1005, 9:33-45, 10:12-14. Using these teachings, "a plan is generated for moving teeth" (a "schedule of movement"). Ex-1005, 10:29-31. Chishti-876 further explains that its system "considers a set of movement constraints which affect the tooth path movement plan," and that such considerations include, for example: "[s]pace," "[t]eeth moving

past each other," "[w]hich teeth are moving when?" and "[w]hich teeth need to be moved before others are moved?" Ex-1005, 11:32-65.

98. As shown in the annotated diagram, Chishti-876's schedule of movement shows for each treatment stage whether each tooth is moving (annotated green for the leftmost tooth) or not moving (annotated red for the leftmost tooth).

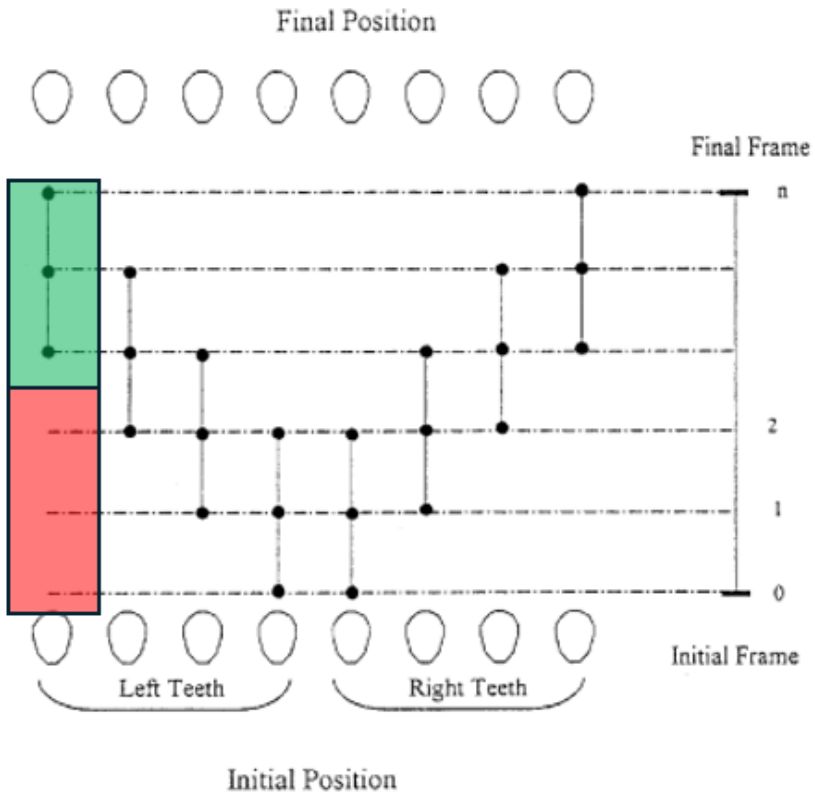


FIG. 11

Ex-1005, Fig. 11, 17:1-7 (annotated). Thus, in my opinion, Chishti-876's schedule of movement indicates whether each of the dental objects moves during each of the treatment stages.

c. [1(b)] calculating, by one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and

99. In my opinion, Chishti-511 discloses this feature. In particular, Chishti-511 teaches that its computer program (Ex-1004, 2:34-39, 3:31-39, 10:19-51) "defines a tooth path" (a respective route) "for the motion of each tooth," which includes "bring[ing] the teeth from their ***initial positions*** to their desired ***final positions***." Ex-1004, 4:7-22 (emphases added); *see also* Ex-1004, 11:4-8 (claiming a "computer-implemented method for segmenting an orthodontic treatment path," which includes moving each "tooth from an initial position to a final position"). Chishti-511's program calculates these paths for each tooth such that "the teeth are moved in the quickest fashion" from start to finish. Ex-1004, 4:7-22. This calculation further involves segmenting the tooth paths into defined steps of the overall treatment path (during the treatment stages). Ex-1004, 4:51-67 (explaining that the segmented tooth paths "are used to calculate clinically acceptable appliance configurations" that "will move the teeth on the defined treatment path in the steps specified by the path segments").

100. As Chishti-511 explains, "each segment [corresponds to] one aligner," allowing for a tooth to move in a desired direction from its initial position to its final position under "an orthodontically optimal amount of force" during each stage. Ex-1004, 4:51-67, 9:15-35.

101. Chishti-511's system further incorporates "a path definition module that calculates the paths taken by teeth as they are repositioned during treatment." Ex-1004, 1:62-67. Thus, Chishti-511's method includes calculating, and continuing to calculate, the treatment path for each tooth during each stage of treatment. *Id.*

d. [1(c)] modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:

102. In my opinion, Chishti-511 alone or in view of Sachdeva renders this limitation obvious. Chishti-511 explains that tooth paths are calculated through an iterative process to generate a schedule of movement, achieving a successful result quickly and safely. Ex-1004, 4:7-22, 4:36-50. Indeed, Chishti-511 explains that its process and system will iteratively modify the segmentations until the system achieves an acceptable movement schedule. Ex-1004, 4:51-5:43, 6:63-7:8, 8:29-9:2, Figs. 4, 6.

103. During Chishti-511's path definition process, portions of the treatment path that are unacceptable (e.g., portions causing collisions among dental objects)

are iteratively redefined. Ex-1004, 8:54-9:14. Indeed, Chishti-511's solution seeks a "clinically viable sequence of tooth positions," moving from an initial position to a final position in stages that "do[] not result in a collision of teeth." Ex-1004, 4:7-22.

104. For example, Chishti-511 describes repeating "the subprocess of defining segmented paths (step 150)" after constraints are applied to the segmented paths. Ex-1004, 4:43-50. Chishti-511 also describes that process 200 for "implementing the appliance-calculation step" applies a finite element analysis "until an exit condition is reached," and thereafter, determinations are made as to whether an acceptable end position is reached by the teeth and that, "[i]f an acceptable end position is not reached by the teeth, the process calculates a new candidate aligner shape (step 240)." Ex-1004, 5:7-30. Similarly, if the tooth motion is not "orthodontically acceptable," the system will also calculate a new aligner shape. *Id.*, 5:27-32. A POSITA would recognize that an acceptable end position will likely not be reached if the tooth movement resulted in a collision and that a schedule of movement resulting in a collision would not be orthodontically acceptable.

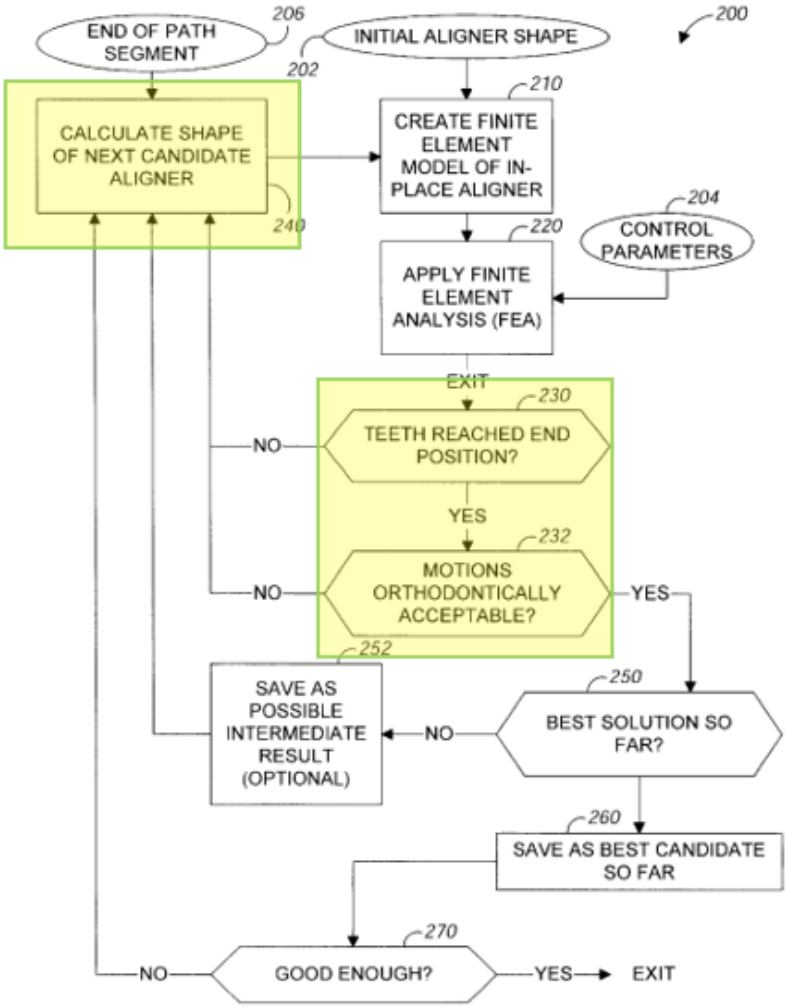


FIG. 2

105. Chishti-511 explains that "[a]ligners may be unacceptable for a variety of reasons." Ex-1004, 8:42-43. A POSITA would have understood that a schedule of movement resulting in a collision would not be orthodontically acceptable. And if there are unacceptable aligners, "the process transfers control to a path definition

process (such as step 150, FIG. 1) to redefine those parts of the treatment path having unacceptable aligners (step 630)." Ex-1004, 8:54-58.

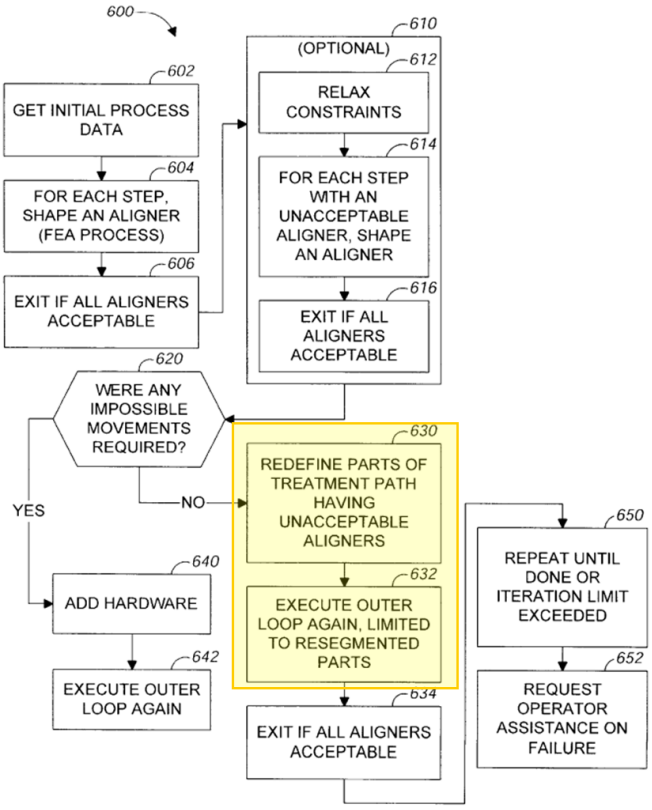


FIG. 6

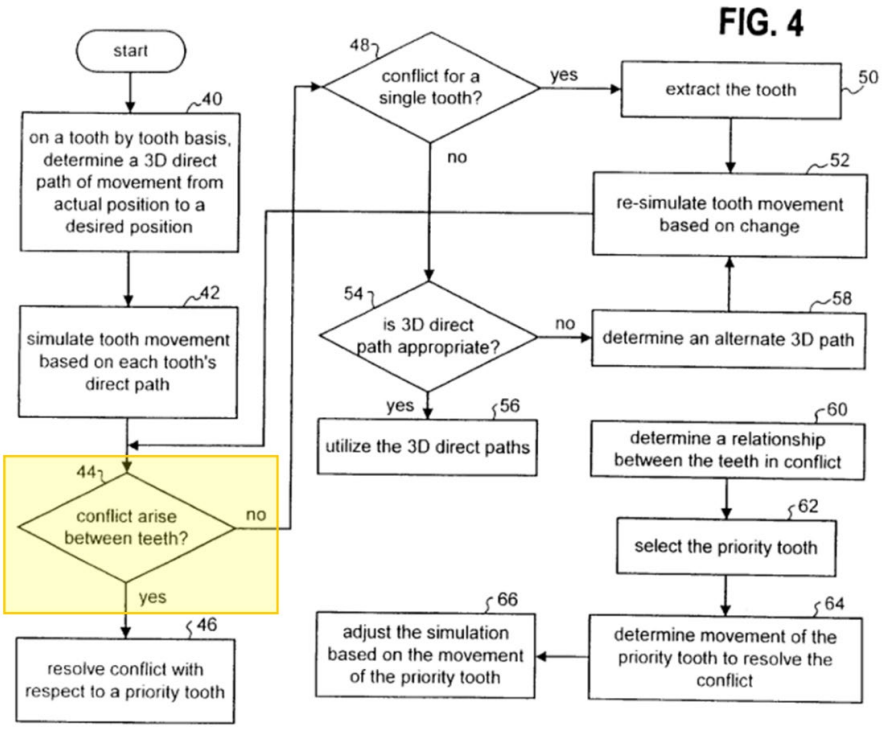
Ex-1004, Fig. 6.

106. "[R]edefin[ing] those parts of the treatment path having unacceptable aligners (step 630)" includes "changing the increments of tooth motion, i.e., changing the segmentation, on the treatment path, changing the path followed by one or more teeth in the treatment path, or both." Ex-1004, 8:54-61. A POSITA would understand that this process involves modifying the schedule of movement.

Thus, Chishti-511 discloses modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes.

107. To the extent it is argued that Chishti-511 does not expressly disclose modifying the schedule of movement "to avoid a collision or obstruction between two of the dental objects on their respective routes," Sachdeva does, in my opinion. And for the reasons discussed in Section VIII, it would have been obvious to modify Chishti-511 to include Sachdeva's collision avoidance and adjustment teachings.

108. During Sachdeva's treatment planning process, the computer determines the three-dimensional path of movement for each tooth between its actual position and its desired position. Ex-1007, 4:39-54. It then simulates each of these treatment paths to determine if "a conflict in movement arose between at least two teeth," and will attempt to resolve it. Ex-1007, 5:3-36, Fig. 4.



Ex-1007, Fig. 4 (annotated).

109. In my opinion, a POSITA would have understood that a conflict arises when there is a collision between two dental objects. Indeed, Sachdeva explains that "[a] conflict may arise [between at least two teeth]" if "the movement of one tooth interferes with the direct path movement of another tooth" (i.e., a collision on their respective routes) "causing a particular tooth to not be able to obtain its desired position." Ex-1007, 5:3-8. The system determines the changes to the movement of the teeth needed to resolve the conflict (modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes) and then adjusts the overall

simulation accordingly. Ex-1007, 5:27-32. As discussed in limitation 1(d), the particular modification disclosed by Sachdeva is delaying, which is further discussed in Section X.A.1.e.

110. Thus, in my opinion, Sachdeva discloses modifying, by one or more computer processors, the schedule of movement to avoid a collision between two of the dental objects based at least on their respective routes.

e. [1(d)] delaying initial movement of one of the dental objects; and

111. In my opinion, Sachdeva discloses this feature. As explained above for limitation 1(c), Sachdeva describes a process for avoiding collisions among teeth, such as the conflict that arises when "the movement of one tooth interferes with the direct path movement of another tooth," causes a collision. Ex-1007, 5:3-8; *supra* Section X.A.1.d. Sachdeva discloses a method for avoiding a collision explaining that where "the lower tooth protrudes preventing the upper tooth from moving back, the lower tooth must be moved before the upper tooth can be positioned" (delaying the upper tooth). Ex-1007, 5:9-26. "Conversely, if the upper tooth is interfering with the lower tooth from being moved out, the upper tooth must first be moved" (delaying the lower tooth). *Id.*

112. In my opinion, a POSITA would have understood that that, normally, teeth will move at the same time if possible. In the examples provided by Sachdeva,

however, two teeth are prevented from initially moving together due to interfering with each other. Thus, Sachdeva discloses delaying the initial movement of the blocked tooth until the obstruction has been cleared. Thus, a POSITA would understand that Sachdeva discloses an instance where, to avoid a collision between two teeth, the initial movement of a dental object must be delayed until another dental object is first moved, as claimed. *Id.*

113. Further, in my opinion, for the reasons explained in Section VIII, it would have been obvious to modify Chishti-511 to include Sachdeva's delaying technique to avoid collisions.

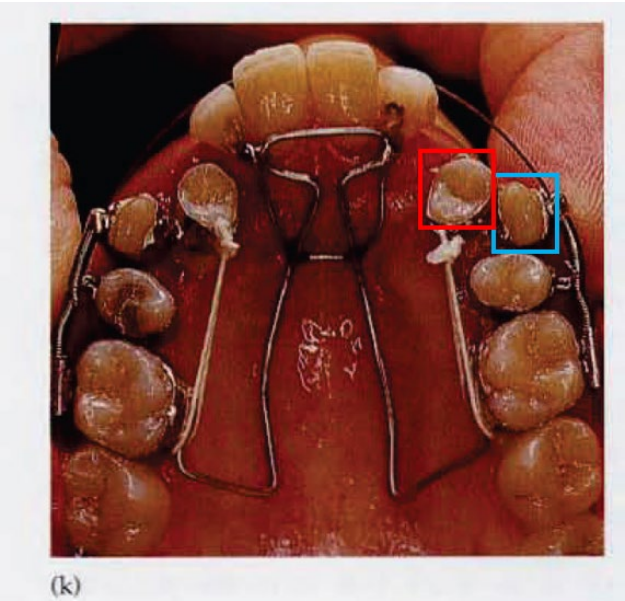
f. [1(e)] round-tripping one of the dental objects.

114. In my opinion, Chishti-511 in view of Sachdeva and Becker renders this limitation obvious. The claim term "round-tripping" has been construed to mean "moving a first tooth out of the path of a second tooth, and once the second tooth has moved sufficiently, moving the first tooth back to its previous position before proceeding to a desired final position of that first tooth." Ex-1013, 8. For the same reasons discussed in Section VIII, a POSITA would have been motivated to modify the combined system to implement Becker's round-tripping collision avoidance.

115. Chishti-511 refers to "round-tripping" as a general type of indirect movement, explaining that "[r]ound-tripping is any motion of a tooth in a direction other than directly toward the desired final position." Ex-1004, 4:7-22. While

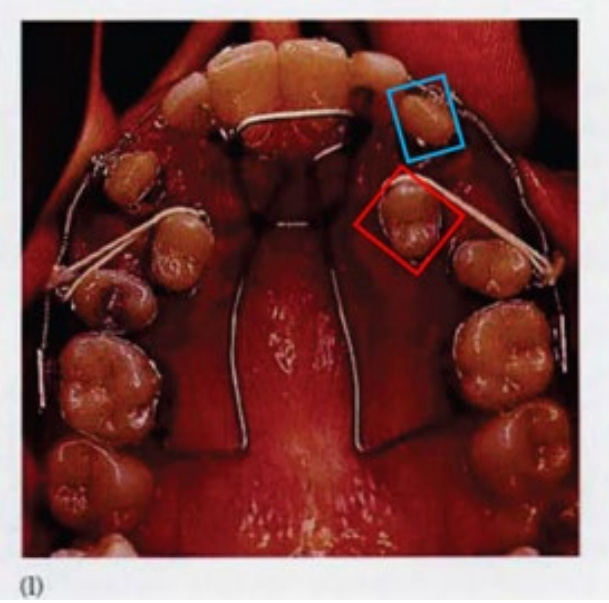
Chishti-511 seeks to move teeth "in the quickest fashion with the least amount of round tripping," it recognizes that "[r]ound-tripping is sometimes necessary to allow teeth to move past each other." *Id.* In my opinion, a POSITA would have understood that round-tripping is a category of movement type that may include different implementations, depending on the treatment needs of a patient. The need for and specifics of a round-tripping motion would depend on a variety of factors, including the specific malocclusion, patient, and treatment goals, but it was a well-known orthodontic practice that could avoid an otherwise unavoidable collision among teeth. For example, round-tripping may be necessary where teeth have erupted in an abnormal position in the dental arch. A POSITA would have understood that in these cases, a collision would result between the teeth if the ectopic teeth is not resolved. In such instances, a POSITA would have understood that resolving such a malocclusion—particularly without extraction—may include round-tripping a tooth.

116. In my opinion, a POSITA would have understood that Becker discloses the claimed round-tripping modification to avoid a collision. Ex-1006, 5. Indeed, Becker presents a malocclusion in which a more lingual tooth ("first tooth," red) is transposed with a more buccal tooth ("second tooth," blue)—such that the more buccal tooth needs to be moved toward the incisors and the midline of the mouth. *Id.*



Ex-1006, 7 (Fig. 8.6(k) (annotated)).

117. As can be seen from Figure 8.6(k) above, moving the more buccal tooth to its proper position would cause a collision between the two teeth. To resolve the transposition, Becker discloses "slid[ing] the more buccal of the transposed teeth (i.e., the tooth closer to the cheek) "in the medio-distal plane" (i.e., toward the midline or center of the dental arch). Ex-1006, 5. To allow this movement, Becker discloses that the more lingual tooth "must be moved further lingually to allow its partner to pass by" ("moving a first tooth out of the path of a second tooth" (Ex-1001, 13:9-13)). Ex-1006, 5. Figure 8.6(l) below depicts the more lingual tooth after it has moved lingually and allowed the more buccal tooth to pass by. Ex-1006, 5.



Ex-1006, 7 (Fig. 8.6(k) (annotated)).

118. After the more lingual tooth is moved "to allow its partner [the more buccal tooth] to pass by," the more lingual tooth moves back to its previous position before proceeding to a desired final position of that first tooth. Ex-1006, 5. In particular, once the more buccal tooth has moved sufficiently, Becker explains that the more lingual tooth "must be moved in the opposite mesio-distal direction and back in the line of the arch." *Id.* A POSITA would understand that moving the more lingual tooth in the "opposite" direction that it previously moved and "back" to where it was before ("in line of the arch") would involve moving the more lingual tooth "back to its previous position" (Ex-1001, 13:9-13). A POSITA would have understood, however, that the more lingual tooth's previous position is not its final position, and thus that further movement is necessary. Thus, Becker shows that the

more lingual tooth continued to move (e.g., along the arch) to proceed to its desired final position. Ex-1006, 5. Indeed, Figure 8.6(m) below shows the more lingual tooth after it proceeds to its desired final position.

Ex-1006, 8 (Fig. 8.6(m) (annotated)).

119. Such a subsequent movement to a final position also would have been obvious to a POSITA, who would have understood that multiple small adjustments are often necessary to achieve a final satisfactory arrangement of teeth (e.g., removing all gaps, precise alignment with other teeth). Becker's subsequent movement to a final position is also consistent with Sachdeva. Sachdeva explains that a "conflict" is where "movement of one tooth interferes with the direct path movement of another tooth[,] causing a particular tooth to not be able to obtain its desired position." Ex-1007, 5:5-8. Thus, a POSITA would have understood that

Sachdeva's disclosure of "mov[ing] [a tooth] sufficiently to resolve the conflict" (Ex-1007, 5:27-30) would result in the previously blocked tooth being able to obtain its desired position. Sachdeva's "process then proceeds to step 66 where the simulation is adjusted based on the movement of the priority tooth." Ex-1007, 5:30-32.

120. A POSITA would recognize that subsequent simulation may cause further movement of the previously blocked tooth toward its final position, and thus, Sachdeva similarly recognizes that a treatment plan may include moving the first tooth further again after resolution of the conflict.

2. Dependent Claim 2: The computer-implemented method of claim 1, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns.

121. In my opinion, Chishti-511 in view of Chishti-876 renders obvious this limitation. For the reasons explained in Section VIII, a POSITA would have been motivated to modify Chishti-511 to include Chishti-876's teachings regarding selecting a movement pattern from a plurality of movement patterns. The '879 patent admits that Chishti-876 disclosed movement patterns. Ex-1001, 6:11-17.

122. Chishti-876 explains that its algorithm draws upon a library of predetermined tooth treatment patterns and its system allows for the selection of "one teeth treatment pattern from a plurality of predetermined teeth treatment

patterns." Ex-1005, Abstract, 2:63-3:10, 3:24-33, 3:38-40, 3:49-51, 14:63-15:4. Each of the proposed treatment patterns presents a "transformation curve" applied to each tooth in order "to move th[at] tooth from its initial position to its final position." Ex-1005, 12:38-43. Chishti-876 explains that its system "generat[es] the malocclusion treatment plan in accordance with the selected treatment pattern." Ex-1005 2:63-3:5, 2:20-24. And Chishti-876 provides several exemplary movement patterns for selection, including how the schedule of movement will be generated based on the selected pattern. Ex-1005, 2:44-62, 3:6-10, 3:24-27, 3:38-40, 3:49-51, 16:48-17:17, Figs. 10-13.

3. Dependent Claim 3: The computer-implemented method of claim 1, further comprising recalculating at least one of the respective routes based on the modified schedule of movement.

123. In my opinion, Chishti-511 discloses this limitation. As explained above, Chishti-511's system will modify the schedule of movement if aligners are unacceptable. In that case, the system "transfers control to a redefinition process … to redefine those parts of the treatment path having unacceptable aligners." Ex-1004, 8:54-65. Chishti-511 explains that this step includes "changing the increments of tooth motion, i.e., changing the segmentation, on the ***treatment path***, ***changing the path*** followed by one or more teeth in the treatment path, or both." *Id.* (emphasis added). Chishti-511 further explains that "this ***recalculation***" is performed for

"those aligners on the ***redefined*** portions of the ***treatment path***." *Id.* (emphasis added). Thus, Chishti-511 discloses recalculating at least one respective route based on the modified schedule of movement.

4. Dependent Claim 4: The computer-implemented method of claim 1, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

124. In my opinion, Chishti-511 discloses this feature. As Chishti-511 explains, each appliance has a specific geometry selected to reposition a tooth from its initial tooth arrangement to a final tooth arrangement. Ex-1004, 1:44-52 ("A patient's teeth are repositioned from an initial tooth arrangement to a final tooth arrangement by making a series of incremental position adjustments using appliances specified in accordance with the invention."). Chishti-511 explains that each "appliance is intended to be worn until [a] first intermediate arrangement is approached or achieved, and then one or more additional (intermediate) appliances are successively placed on the teeth." Ex-1004, 1:33-58; *see also* Ex-1004, 4:51-67 (explaining that each appliance configuration represents a step or treatment stage along the treatment path and segmented tooth paths are then "used to calculate clinically acceptable appliance configurations."); *see also supra* Sections X.A.1.b-c [1(a) and 1(b)] (discussing treatment stages). Thus, each of the orthodontic

appliances (at least two orthodontic aligners) in Chishti-511 corresponds to a respective one of the treatment stages.

125. Chishti-511 further discloses that the appliances are manufactured after the specific tooth paths are redefined and acceptable. Indeed, as shown in Chishti-511's Figure 1 below, the repositioning appliances are manufactured, producing an appliance for each step of the treatment path defined by the segmentation:

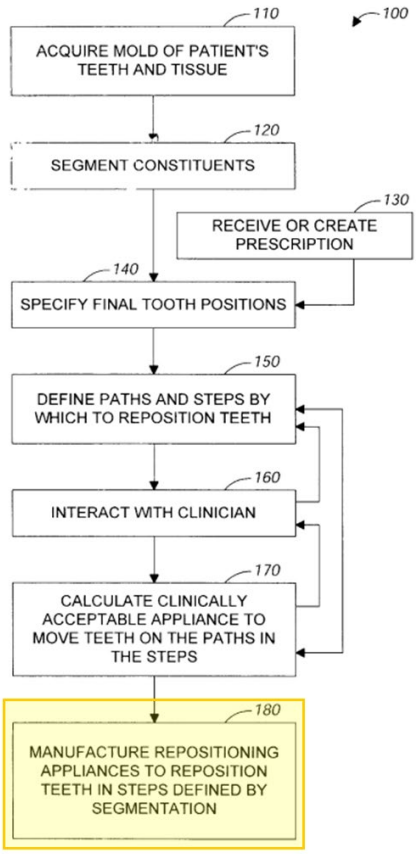


FIG. 1

Ex-1004, Fig. 1 (annotated); *see also* Ex-1004, 5:1-6; *see also id.* 3:36-39 (describing "manufacturing step (step 180)" as the step "in which appliances defined by the process are manufactured."), 10:19-51.

5. Dependent Claim 5

a. [5(a)] The computer-implemented method of claim 4, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and

126. In my opinion, Chishti-511 discloses this feature. It explains that its manufacturing process relies on the "generation of positive models to produce the repositioning appliance[s]," and that "adding a wax patch to the digital model will generate a positive mold that has the same added wax patch geometry." Ex-1004, 9:43-56. As explained above, each appliance configuration represents one stage (of multiple) along the treatment path. Ex-1004, 4:51-67. Therefore, for each of the multiple aligners, a respective positive physical model of the patient is created from the digital scan. Ex-1004, 9:43-56. Then, the "aligner is manufactured by pressure fitting polymeric material over a positive physical model of the digital teeth," respective to that stage of the treatment path. *Id.*

127. In my opinion, a POSITA would have understood that because this manufacturing process produces the aligners for each stage of the movement pattern, this fabrication would be required for at least two of the treatment stages, as claimed.

b. [5(b)] thermoforming an orthodontic aligner over each respective positive mold.

128. In my opinion, Chishti-511 alone or in view of Chishti-876 renders this limitation obvious. As explained above, Chishti-511 discloses that the aligners may be manufactured by pressure fitting polymeric material over a positive physical model of the digital teeth. Ex-1004, 9:43-56. A POSITA would have understood that the ’879 patent’s claimed “thermoforming” fabrication is disclosed by Chishti-511’s pressure fitting manufacturing process. A POSITA would have understood that thermoforming is a well-known manufacturing process whereby a plastic sheet is heated to a pliable temperature, shaped into a specific form using a mold, and then cooled to maintain its new shape. Pressure-fitting a polymeric material over a positive physical model of teeth—as disclosed in Chishti-511—would be understood by a POSITA to be a type of thermoforming, as pressure-fitting uses air pressure in conjunction with the heated plastic sheet to help shape the appliance in the form of the mold. Indeed, the ’879 patent this was known—the specification’s only mention of a manufacturing technique describes “using a ***conventional pressure molding*** technique to form the appliance around the positive mold.” Ex-1001, 3:42-46 (emphasis added). Thus, the ’879 patent admits that the required fabrication process was merely “conventional,” (*id.*), and a POSITA would have understood that the ’879 patent’s conventional manufacturing process, which is consistent with and

matches Chishti-511's disclosure of pressure fitting, makes this limitation disclosed and rendered obvious by Chishti-511.

129. To the extent it is argued that Chishti-511 does not disclose this feature, this limitation is rendered obvious by Chishti-876. Chishti-876 explains that its dental appliances may be a "polymeric shell" configured to receive a patient's teeth and reposition them into an intermediate or final tooth arrangement. Ex-1005, 7:1-18. To manufacture these dental appliances, Chishti-876 uses known methods, such as forming the appliances "from a thin sheet of a suitable elastomeric polymer, such as Tru-Tain 0.03 in, ***thermal forming*** dental material, available from Tru-Tain Plastics, Rochester, Minn." Ex-1005, 7:54-64 (emphasis added). A POSITA would understand that the disclosed thermal forming dental material would create Chishti-876's polymeric shells through the process of thermoforming the dental material over a respective positive mold (as described in Chishti-511).

130. In my opinion, a POSITA also would have been motivated to consider the teachings of Chishti-876 regarding the manufacture of dental aligners disclosed in Chishti-511. Chishti-511 discloses that the aligners may be manufactured by pressure fitting polymeric material over a positive physical model of the digital teeth. Ex-1004, 9:43-56. A POSITA would have been motivated to look to ways to manufacture the generated aligners, and Chishti-876 discloses known methods for manufacturing these dental appliances. Ex-1005, 7:54-64.

131. In my opinion, the use of thermoforming for appliance manufacturing would have had a reasonable expectation of success, as thermoforming is just one of a finite number of identified, predictable solutions, and was a well-known and routine technique for aligner manufacturing at the relevant time. The ’879 patent’s specification does not purport to have invented the technique. *See, e.g.*, Ex-1001, 3:42-46 (“One technique for producing an orthodontic appliance involves creating a positive mold of the patient’s dentition at one of the treatment stages and using a conventional pressure molding technique to form the appliance around the positive mold.”). The state of the art also confirms this technique was known. Ex-1016, 198 (“A thermoforming process is used for aligner fabrication. A thermoplastic sheet is first heated and then a vacuum/pressure thermoforming process is used to form the aligner. The hot sheet is drawn down over a stereolithographic (SLA) model of the patient’s dental anatomy. Pressure and vacuum forces cause the material to adapt or conform to the SLA model.”); Ex-1016, 18-23 (describing the history of thermoforming and explaining that a thermoforming technique was first used to fabricate dental appliances in 1959). A POSITA also would have had a reasonable expectation of success in combining these teachings, given that thermoforming was a well-known manufacturing option at the time. Accordingly, it would have been obvious to a POSITA at the relevant time to combine Chishti-876’s disclosure of thermoforming with Chishti-511’s disclosure of manufacturing the dental aligners.

6. Dependent Claim 6

a. [6(a)] The computer-implemented method of claim 1, wherein the round-tripping comprises: moving a first of the dental objects away from the respective route of a second of the dental objects; and

132. Because limitation 6(a) is substantively identical to a portion of the previously applied round-tripping construction, in my opinion, Becker discloses this feature for the same reasons discussed with respect to limitation 1(e) above. *Supra* Section X.A.1.f. Limitation 6(a) merely recites that the first dental object is moved "away" from the route of the second object, which Becker discloses, as it discloses a first tooth moved "out of the path of a second tooth" as required by the round-tripping construction. *Id.*

b. [6(b)] moving the first dental object toward its respective final position after the second dental object has sufficiently traversed its respective route to avoid the collision.

133. Because limitation 6(b) is substantively identical to a portion of the previously applied round-tripping construction, in my opinion, Becker discloses this feature for the same reasons discussed with respect to limitation 1(e) above. *Supra* Section X.A.1.f. Limitation 6(b) merely recites that the first dental object is moved "toward" its final position after the second object has sufficiently traversed its respective route "to avoid the collision." As explained with respect to limitation 1(e), this is met by Becker, as it discloses that the first dental object moves "to its previous

position" and then moves to its previous and then respective final position (and hence toward it). *Id.* Becker similarly discloses that the first tooth will also only move toward its final position after the second tooth has "allow[ed] its partner to pass by" (after the second dental object has sufficiently traversed its respective route to avoid the collision). Ex-1006, 5.

7. Dependent Claim 7

a. [7(a)] The computer-implemented method of claim 1, wherein the round-tripping comprises: moving a first of the dental objects away from the respective route of a second of the dental objects; and

134. In my opinion, Chishti-511 discloses this feature for the same reasons discussed with respect to limitations 1(e) and 6(a) above. *Supra* Sections X.A.1.f, X.A.6.a.

b. [7(b)] moving the first dental object toward its previous position.

135. In my opinion, because limitation 7(b) is substantively identical to a portion of the previously applied round-tripping construction, Becker discloses this feature for the same reasons discussed with respect to limitation 1(e). *Supra* Section *Supra* Sections X.A.1.f. Limitation 7(b) merely recites that the first dental object moves "toward" its previous position. As explained with respect to limitation 1(e), this is met by Becker, as it discloses that the first dental object moves "to its previous position" (and hence towards it).

8. Dependent Claim 8

a. [8(a)] The computer-implemented method of claim 1, wherein: the determining of the schedule of movement comprises determining, by one or more computer processors, a total number of the treatment stages; and

136. In my opinion, Chishti-511 alone or in view of Chishti-876 renders this limitation obvious.

137. Chishti-511 discloses segmenting its treatment plan into stages. Specifically, it optimizes tooth paths "so that the teeth are moved [to their desired final position] in the quickest fashion" without exceeding safety or discomfort thresholds. Ex-1004, 4:7-22. As explained above for limitation 1(a), these "tooth paths are segmented" into a calculated number of segments "so that each tooth's motion within a segment stays within threshold limits of linear and rotational translation." *Id.*; *supra* Section X.A.1.b. The segmented tooth paths are then "used to calculate clinically acceptable appliance configurations . . . that will move the teeth on the defined treatment path in the steps specified by the path segments." Ex-1004, 4:51-67. "Each appliance configuration represents a step along the treatment path" and is designed to apply "an orthodontically optimal amount of force on the patient's dentition" to "move the teeth on the defined treatment path in the steps" toward their respective final positions. *Id.* Chishti-511 discloses that "the aggregate of segment end points constitute[s] a clinically viable sequence of tooth positions."

Ex-1004, 4:18-22. In my opinion, a POSITA would understand that the number of steps/appliances is the total number of treatment stages.

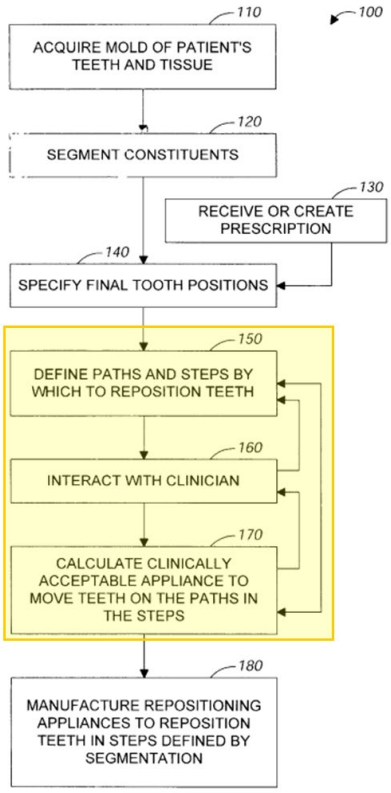


FIG. 1

Ex-1004, Fig. 1 (annotated); *see also id.*, Fig. 6 ("For each step, shape an aligner," which continues until "all aligners" are acceptable); *see also* Ex-1004, 5:1-6 (disclosing manufacturing the appliances, which would correspond to the total number of treatment stages).

138. Thus, in my opinion, a POSITA would have understood from Chishti-511 that, when calculating the clinically acceptable appliances (and iterating through

them), the system determines a total number of treatment stages. Indeed, to know when "all" aligners are acceptable, and to iterate through the number of steps and create corresponding aligners, the system would calculate the total number of stages to identify when that process was complete.

139. To the extent it is argued that Chishti-511 does not alone disclose determining a total number of treatment stages, this limitation is obvious in view of Chishti-876. Indeed, Chishti-876 discloses optimizing the movement pattern of each tooth to reduce the movement steps. Ex-1005, 11:26-40. It also indicates it has calculated the treatment stages, noting that one treatment plan includes "about fifty discrete stages," where each stage represents a single aligner in the treatment plan. *Id.* Thus, Chishti-876 expressly discloses calculating the number of treatment stages. And for the reasons explained in Section VIII, it would have been obvious to modify Chishti-511 to include Chishti-876's teachings regarding this feature.

b. [8(b)] the determining of the total number of the treatment stages comprises: determining, by one or more computer processors, a respective minimum number of treatment stages for each of the dental objects; and

140. In my opinion, Chishti-511 alone or in view of Chishti-876 renders this limitation obvious.

141. Because Chishti-511 discloses calculating the number of segments necessary to move "the teeth from their initial positions to their desired final

positions" in the "quickest fashion." Ex-1004, 4:7-22. And in calculating its aligners, Chishti-511 considers inputs such as "the maximum allowable displacement velocity for each tooth and the maximum allowable force of each kind for each tooth." Ex-1004, 6:38-56. In my opinion, a POSITA would have understood that to achieve the desired final position of each tooth in the "quickest" manner possible, while considering the maximum amount the system can move teeth for each aligner, Chishti-511 determines the minimum number of treatment stages for each dental object. Ex-1004, 4:7-22, 6:38-56.

142. If it is argued that Chishti-511 does not alone disclose this feature, this limitation would have been obvious in view of Chishti-876. Chishti-876 discloses "finding a collision[-]free shortest path between an initial position and a final position for one or more teeth." Ex-1005, claim 3. Chishti-876 also analyzes the "maximum linear or rotational velocity at which a tooth should move, [and] the maximum distance over which a tooth should move between treatment steps." Ex-1005, 13:49-14:4. Because this repositioning happens in the "quickest fashion" and achieves the maximum allowable speed to the desired result , a POSITA would have understood, that Chishti-876 determines the minimum number of treatment stages for each tooth.

143. Moreover, Chishti-876 discloses an all-equal movement pattern in which each tooth travels "approximately equal lengths between each adjacent pair

of treatment steps." Ex-1005, 13:49-55, 16:57-67, Fig. 10. Chishti-876 explains that "X-type movement[,] . . . also known as an 'All Equal Movement,'" involves "all teeth in a given group . . . moving at the same time." Ex-1005, 16:57-67. This is accomplished by taking the overall distance between each of the initial and final positions and dividing them in half repeatedly until "the moving distance in each frame meets a given criterion." *Id.*; *see also* Ex-1005, Fig. 10. The system then adjusts the teeth movement "so that each frame does not exceed one or more distance constraints." Ex-1005, 16:57-67. By repeatedly performing this process until distance constraints are not exceeded, Chishti-876's system moves the teeth as far as possible without exceeding the distance constraints, which a POSITA would understand would result in a minimum number of treatment stages for each tooth. And for the reasons discussed in Section VIII, a POSITA would have been motivated to combine Chishti-876's disclosed stage calculations and treatment patterns with Chishti-511.

c. [8(c)] selecting, by one or more computer processors, a largest of the respective minimum numbers of treatment stages as the total number of the treatment stages.

144. In my opinion, Chishti-511 in view of Chishti-876 renders this limitation obvious. As explained above, Chishti-511 teaches a process to reposition dental objects in the "quickest fashion" possible. Ex-1004, 4:7-22. This includes

analyzing the maximum speed and distance of repositioning in the minimum number of treatment stages for each dental object being moved. *Supra* Section X.A.8.b [8(b)].

145. In my opinion, a POSITA would have understood that to achieve the desired result for each dental object, each tooth must move at least its own minimum number of treatment stages. A POSITA would thus recognize that, for the tooth having the largest number of stages, the overall number of treatment stages could not be less than that. This would accordingly set the minimum number of stages for the overall treatment plan to the minimum number of stages required to move all teeth to their desired final positions. Using less than the largest of the minimum number of stages would result in an incomplete treatment plan, and using more than the largest of the minimum number of stages would add unnecessary time and expense to the overall treatment plan. Thus, in a situation where the most posterior tooth required a minimum of 10 stages, but each other tooth could accomplish its desired movement in 7 stages or less, a POSITA would have understood that 10 stages (as the largest of the respective minimum number of stages) would need to be selected as the total number of stages for the overall plan because selecting anything less than 10 stages would fail to achieve the desired final position for the most posterior tooth.

146. Moreover, Chishti-876 discloses where the largest of the respective minimum numbers of treatment stages is selected as the total number of the treatment stages. Chishti-876 provides an example, in Figure 10 below, of an X-type movement pattern where each tooth reaches its desired final position in the same number of treatment stages:

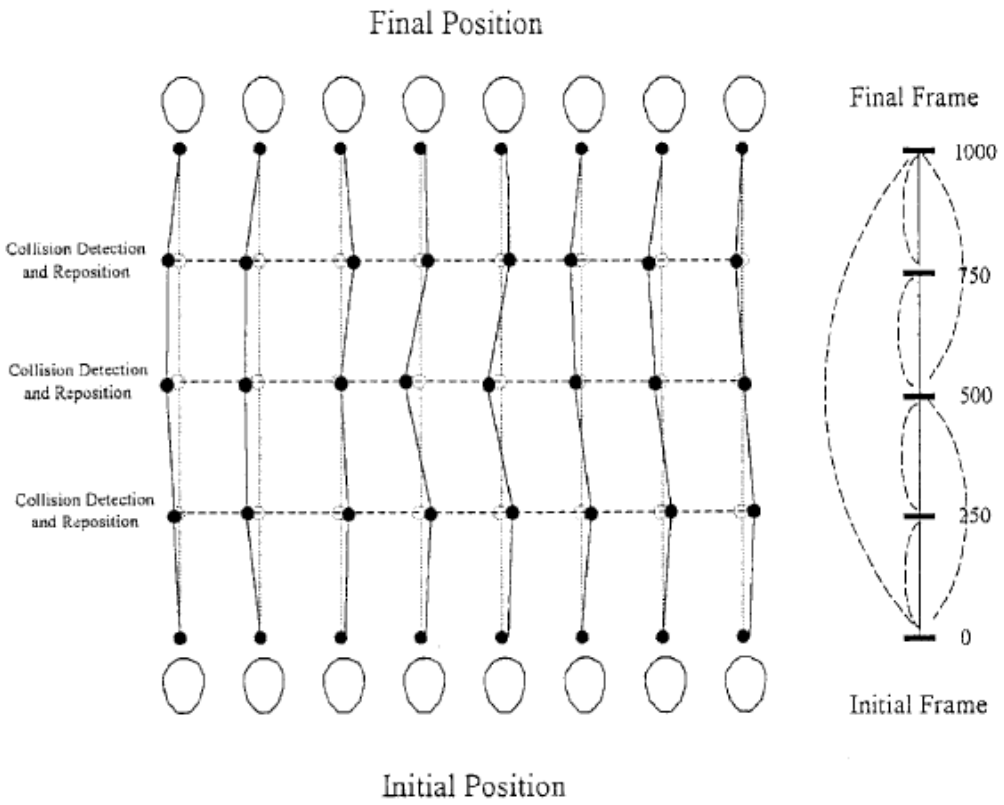


FIG. 10

See Ex-1005, Fig. 10.

147. In accordance with this example, Chishti-876 selects the largest of the respective minimum number of treatment stages as the total number of treatment stages for the treatment plan. And for the reasons discussed in Section VIII, a POSITA would have been motivated to combine Chishti-876's disclosed treatment patterns with Chishti-511.

148. Regardless of whether, for example, an X-type movement pattern applies, a POSITA would have thus understood that if a certain tooth requires a greater number of steps than other teeth, the number of stages for that tooth dictates the total number of stages needed for the overall treatment plan because that would be the minimum number of stages required to move all teeth and complete the treatment plan. Thus, to the extent it is argued that Chishti-876 does not specifically disclose selecting a largest of the respective minimum number of treatment stages as the total number of treatment stages, this limitation is at least rendered obvious by Chishti-876.

9. Independent Claim 9

149. Claim 9 repeats, or recites, features that are substantively identical to features recited in claim 1, with the exception of differing language in the preamble and removal of "by one or more computer processors." *Compare* Ex-1001, 16:9-27, *with* Ex-1001, 17:5-23. The table below shows the correspondence between the claims.

Claim 1	Claim 9
[1(pre)] A computer-implemented method comprising:	[9(pre)] A non-transitory computer-readable medium comprising instructions that, when executed by one or more computer processors, cause at least one of the one or more computer processors to:
[1(a)] determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;	[9(a)] determine a schedule of movement for dental objects during treatment stages, the dental objects being based from output from a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;
[1(b)] calculating, by one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and	[9(b)] calculate a respective route from an initial position toward a desired final position for each of the dental objects during the treatment stages; and
[1(c)] modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:	[9(c)] modify the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:
[1(d)] delaying initial movement of one of the dental objects; and	[9(d)] delaying initial movement of one of the dental objects; and
[1(e)] round-tripping one of the dental objects.	[9(e)] round-tripping one of the dental objects.

150. Accordingly, claim limitations 9(pre)-9(e) are taught or suggested for the reasons discussed here and in Sections X.A.1.a-.f, which discuss the corresponding portions of claim 1.

a. [9(pre)] A non-transitory computer-readable medium comprising instructions that, when executed by one or more computer processors, cause at least one of the one or more computer processors to:

151. In my opinion, Chishti-511 discloses this feature for the same reasons discussed with respect to limitation 1(pre). As discussed previously, Chishti-511 discloses that its system can be implemented in "computer programs" that are executed on "at least one programmable processor." Ex-1004, 10:29-43; *see also* Section X.A.1.a. Chishti-511 also discloses "[s]torage devices suitable for tangibly embodying computer program instructions" and provides various examples of non-transitory computer-readable medi[a], including "all forms of nonvolatile memory," "flash memory devise," "internal hard disks and removable disks," "CD-ROM disks," and more. Ex-1004, 10:43-51.

b. [9(a)] determine a schedule of movement for dental objects during treatment stages, the dental objects being based from output from a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;

152. In my opinion, this limitation is disclosed or rendered obvious for the same reasons discussed with respect to limitation 1(a). *Supra* Section X.A.1.b.

c. [9(b)] calculate a respective route from an initial position toward a desired final position for each of the dental objects during the treatment stages; and

153. In my opinion, this limitation is disclosed or rendered obvious for the same reasons discussed with respect to limitation 1(b). *Supra* Section X.A.1.c.

d. [9(c)] modify the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:

154. In my opinion, this limitation is disclosed or rendered obvious for the same reasons discussed with respect to limitation 1(c). *Supra* Section X.A.1.d.

e. [9(d)] delaying initial movement of one of the dental objects; and

155. In my opinion, this limitation is disclosed or rendered obvious for the same reasons discussed with respect to limitation 1(d). *Supra* Section X.A.1.e.

f. [9(e)] round-tripping one of the dental objects.

156. In my opinion, this limitation is disclosed or rendered obvious for the same reasons discussed with respect to limitation 1(e). *Supra* Section X.A.1.f.

10. Dependent Claim 10: The medium of claim 9, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns.

157. Claim 10 repeats or recites features that are substantively identical to features recited in claim 2, except for the preamble. *Compare* Ex-1001, 16:28-32,

with Ex-1001, 17:24-27. In my opinion, claim 10 is obvious for the same reasons as provided for claim 2. *Supra* Section X.A.2.

158. The table below shows the correspondence between the claims.

Claim 2	Claim 10
The computer-implemented method of claim 1, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns.	The medium of claim 9, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns.

11. Dependent Claim 11: The medium of claim 9, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to recalculate at least one of the respective routes based on the modified schedule of movement.

159. Claim 11 repeats or recites features that are substantively identical to features recited in claim 3, except for the preamble and reciting "wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to …". *Compare* Ex-1001, 16:33-35, *with* Ex-1001, 17:28-32. In my opinion, claim 11 is disclosed or rendered obvious for the same reasons as provided for claim 3. *Supra* Section X.A.3.

160. The table below shows the correspondence between the claims.

Claim 3	Claim 11
The computer-implemented method of claim 1, further comprising recalculating at least one of the respective routes based on the modified schedule of movement.	The medium of claim 9, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to recalculate at least one of the respective routes based on the modified schedule of movement.

12. Dependent Claim 12: The medium of claim 9, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to control manufacture of at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

161. Claim 12 repeats or recites features that are substantively identical to features recited in claim 4, except for the preamble and reciting "wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to …". *Compare* Ex-1001, 16:36-39, *with* Ex-1001, 17:33-38. In my opinion, claim 12 is disclosed or rendered obvious for the same reasons provided for claim 4. *Supra* Section X.A.4.

162. The table below shows the correspondence between the claims.

Claim 4	Claim 12
The computer-implemented method of claim 1, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.	The medium of claim 9, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to control manufacture of at least two orthodontic

	aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

13. Dependent Claim 13: The medium of claim 12, wherein the manufacture comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and thermoforming an orthodontic aligner over each of the respective positive molds.

163. Claim 13 repeats or recites features that are substantively identical to features recited in claim 5, except for the preamble. *Compare* Ex-1001, 16:40-45, *with* Ex-1001, 17:39-44. In my opinion, claim 13 is disclosed or rendered obvious for the same reasons provided for claim 5. *Supra* Section X.A.5.

164. The table below shows the correspondence between the claims.

Claim 5	Claim 13
[5(a)] The computer-implemented method of claim 4, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and	[13(a)] The medium of claim 12, wherein the manufacture comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and
[5(b)] thermoforming an orthodontic aligner over each respective positive mold.	[13(b)] thermoforming an orthodontic aligner over each of the respective positive molds.

14. Independent Claim 14

165. Claim 14 repeats or recites features that are substantively identical to features recited in claim 8, except for the preamble and that claim 14 does not recite

that a claimed feature is performed by one or more computer processor. *Compare* Ex-1001, 16:58-17:4, *with* Ex-1001, 17:45-54. In my opinion, claim 14 is taught or suggested for the reasons discussed for claim 8. *Supra* Section X.A.8.

166. The table below shows the correspondence between the claims.

Claim 8	**Claim 14**
[8(a)] The computer-implemented method of claim 1, wherein: the determining of the schedule of movement comprises determining, by one or more computer processors, a total number of the treatment stages; and	[14(a)] The medium of claim 9, wherein: the determining of the schedule of movement comprises determining a total number of the treatment stages; and
[8(b)] the determining of the total number of the treatment stages comprises: determining, by one or more computer processors, a respective minimum number of treatment stages for each of the dental objects; and	[14(b)] the determining of the total number of the treatment stages comprises: determining a respective minimum number of treatment stages for each of the dental objects; and
[8(c)] selecting, by one or more computer processors, a largest of the respective minimum numbers of treatment stages as the total number of the treatment stages.	[14(c)] selecting a largest of the respective minimum numbers of treatment stages as the total number of the treatment stages.

15. Independent Claim 15

a. [15(pre)]-[15(c)]: A computer-implemented method comprising:

determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;
calculating, by the one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and
modifying, by the one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising

167. Limitations 15(pre)-15(c) repeat or recite features that are substantively identical to features recited in limitations 1(pre)-1(c), respectively. *Compare* Ex-1001, 16:9-24, *with* Ex-1001, 17:55-18:2. The table below shows the correspondence between the claims.

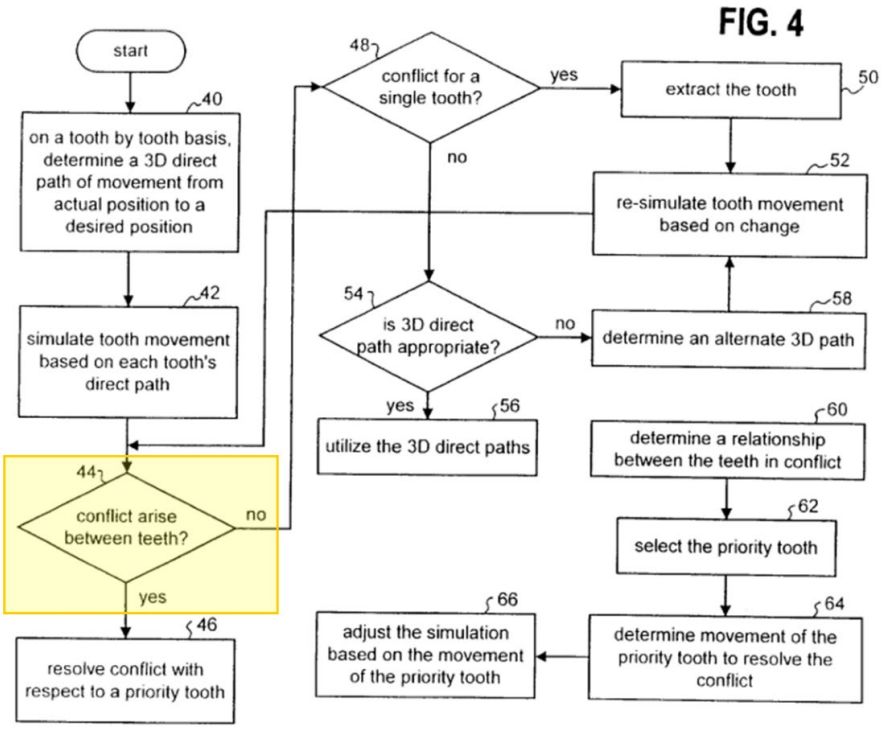
Limitations 1(pre)-1(c)	Limitations 15(pre)-15(c)
[1(pre)] A computer-implemented method comprising:	[15(pre)] A computer-implemented method comprising:
[1(a)] determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;	[15(a)] determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;

[1(b)] calculating, by one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and	[15(b)] calculating, by the one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and
[1(c)] modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:	[15(c)] modifying, by the one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:

168. In my opinion, limitations 15(pre)-15(c) are obvious for the same reasons provided for the corresponding portions of claim 1, namely limitations 1(pre)-1(c). *Supra* Sections X.A.1.a-.d [1(pre)-1(c)].

b. [15(d)] determining, by the one or more computer processors, that the respective route of a first of the dental objects results in a collision or obstruction with a second of the dental objects;

169. In my opinion, Chishti-511 in view of Sachdeva renders this limitation obvious for the same reasons provided for limitation 1(c). *Supra* Section X.A.1.d. As described with respect to limitation 1(c), Sachdeva discloses that its system will determine if "a conflict in movement arose between at least two teeth," and will attempt to resolve it. Ex-1007, 5:3-8, Fig. 4. Sachdeva explains that a conflict (a collision) may arise if the treatment path (route) of one tooth interferes with the treatment path (route) of another tooth (i.e., a collision), thereby causing either tooth to be unable to reach its desired position. Ex-1007, 5:3-8.



Ex-1007, Fig. 4 (annotated).

c. [15(e)] altering, by the one or more computer processors in response to the determining, the schedule of movement by delaying initial movement of the first dental object;

170. Limitation 15(e) repeats or recites features that are substantively identical to features recited in claim limitations 1(c) and 1(d). *Supra* Sections X.A.1.d-.e. In my opinion, this limitation is obvious for the same reasons provided for those limitations.

171. The table below shows the correspondence between the claims.

Limitations 1(c)-1(d)	Limitation 15(e)
[1(c)] modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:	[15(e)] altering, by the one or more computer processors in response to the determining, the schedule of movement by delaying initial movement of the first dental object;
[1(d)] delaying initial movement of one of the dental objects; and	

172. Limitation 15(e) recites "altering … the schedule of movement by delaying initial movement" whereas 1(c) recites "modifying … the schedule of movement . . . [by] delaying initial movement." Moreover, limitation 15(e) recites altering "in response to the determining" of limitation 15(d), which is "determining . . . that the respective route of a first of the dental objects results in a collision." Limitation 1(c) likewise recites modifying "to avoid a collision or obstruction between two of the dental objects on their respective routes." These are substantively identical, and thus in my opinion, this limitation is obvious for the same reasons provided for limitations 1(c) and 1(d). *Supra* Sections X.A.1.d-.e.

d. [15(f)] determining, by the one or more computer processors, that the altered schedule of movement still results in a collision or obstruction involving the first dental object; and

173. In my opinion, Chishti-511 in view of Sachdeva renders this feature obvious. As explained above for limitations 1(c) and 15(d), the combination will

determine if there will be a collision between dental objects and perform a modification, using delaying and round-tripping, to avoid the collision. *Supra* Sections X.A.15.b, X.A.1.d-.f. Limitation 15(f) recites determining if the "altered schedule of movement" results in a collision, whereas 15(d) recites determining if the "route[s]" result in a collision. This limitation is met for the same reasons discussed for 1(c) and 15(d). *Id.* Indeed, Chishti-511 discloses that its segmented tooth paths are "used to calculate clinically acceptable appliance configurations . . . that will move the teeth on the defined treatment path in the steps specified by the path segments." Ex-1004, 4:51-67. Thus, the schedule of movement takes into account the routes of teeth, and the combined system will determine if the schedule of movement results in a collision. Further, Chishti-511 states that its segments are constructed so that "moving from one point to the next *in the sequence* does not result in a collision of teeth." Ex-1004, 4:7-22. Thus, it determines whether the schedule of movement will result in a collision.

174. Chishti-511 will also determine if the schedule of movement "still results" in a collision. During Chishti-511's "path definition process," it will redefine the segments of the treatment path that are unacceptable, such as those portions causing two dental objects to collide. Ex-1004, 8:54-9:14, Fig. 6. Indeed, a POSITA would have understood that a treatment path causing two dental objects to collide during the treatment would result in unacceptable aligners, since Chishti-

511's overall goal is to incrementally reposition teeth in a clinically viable sequence of movements that "does not result in a collision of teeth." Ex-1004, 4:18-22.

175. Chishti-511 explains that "[a]fter the treatment path has been redefined" to account for the unacceptable aligners, the process is re-executed to ensure all aligners are now acceptable (e.g., the collision has been resolved and there are no further collisions). Ex-1004, 8:54-9:2, Fig. 6.

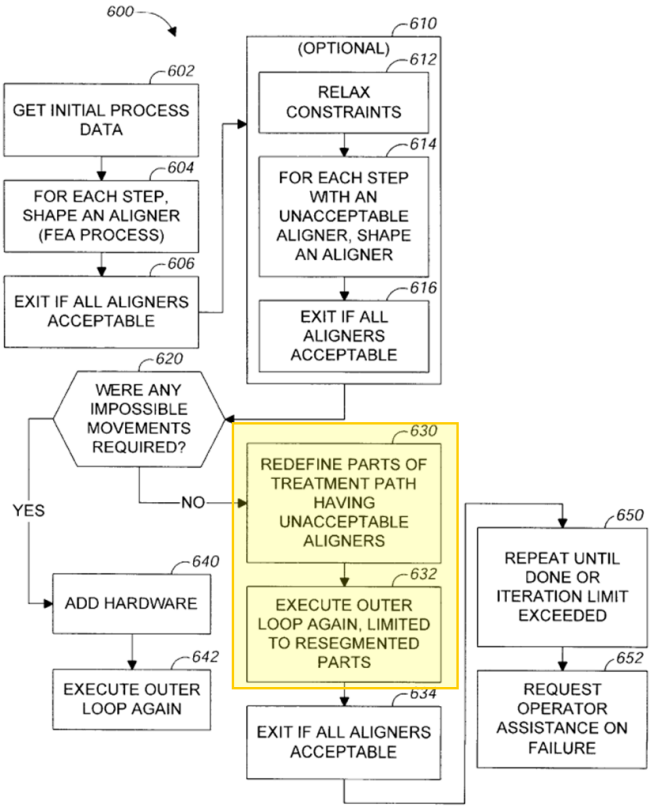


FIG. 6

Ex-1004, Fig. 6 (annotated)

176. As the process re-executes, it will determine whether unacceptable aligners still remain, the process repeats, performing additional determinations of whether of collisions still result, and modifications or redefinitions "until an acceptable set of aligners is found." Ex-1004, 8:54-9:14. This repeated process would include determining the existence of collisions as discussed for limitations 15(d) and 1(c). Thus, in my opinion, because Chishti-511 (in view of Sachdeva) continues to check if the aligners are acceptable, including determining whether the schedule of movement results in a collision, its process makes a determination regarding whether the first alteration (i.e., delaying) successfully avoided the collision between the first and second dental objects and thus whether the altered schedule of movement still results in a collision or obstruction involving the first dental object. This is also consistent with the teaching of Chishti-876, which "applies the collision detection algorithm" to its treatment paths to determine if the proposed path will cause collisions between teeth. Ex-1005, 13:10-48. "If any collisions are detected, the program alters the path of at least one tooth in each colliding pair," creates a new path, and "then samples the new path (1604) and again applies the collision detection algorithm." *Id.* Chishti-876 explains that this "program continues in this manner until no collisions are detected." *Id.*

e. [15(g)] altering, by the one or more computer processors after the determining that the altered schedule of movement still results in a collision or

> **obstruction, the schedule of movement of the first dental object by moving the first dental object out of the path of the second dental object, and once the second dental object has moved sufficiently, moving the first dental object back to the first dental object previous position before proceeding to a desired final position of the first dental object.**

177. In my opinion, Chishti-511 in view of Sachdeva and Becker renders this limitation obvious. As explained above for limitations 1(c) and 1(e), the combination will modify (or alter) the schedule of movement to avoid a collision, including by round-tripping one of the dental objects, and limitation 15(f) explains that the combination will determine if a collision will still result. *Supra* Sections X.A.1.d, X.A.1.f, X.A.15.e. Claim 15(g) merely recites that the system will perform round-tripping of the first dental object if it determines collision will still result, as the alteration of the schedule of movement recited is the construction for round-tripping. *See* Section V. This limitation is met for the same reasons discussed in limitations 1(e) and 15(f). *Supra* Sections X.A.1.f, X.A.15.e.

178. As discussed previously, Chishti-511 discloses that, following aligner modifications, its process is re-executed to ensure all aligners are now acceptable (e.g., the collision has been resolved and there are no further collisions). Ex-1004, 8:54-9:2, Fig. 6. As the process re-executes, if it determines a collision exists, it will perform additional alterations or redefinitions of the schedule of movement/aligners "until an acceptable set of aligners is found." Ex-1004, 8:54-9:14. As discussed with

respect to limitation 1(e), one potential modification for the combination would be to attempt to round-trip the first dental object. *Supra* Sections X.A.1.f.

179. Thus, a POSITA would have understood Chishti-511 to disclose an iterative process for altering the schedule of movement until one is found that is acceptable and avoids collisions, which, in view of Becker, would include altering the schedule of movement to round-trip the dental objects. A POSITA also would have understood that modifying a schedule of movement to include round-tripping is simply combining prior art elements according to known methods to yield predictable results.

16. Dependent Claim 16: The computer-implemented method of claim 15, further comprising recalculating at least one of the respective routes based on the modified schedule of movement.

180. Claim 16 repeats or recites features that are substantively identical to features recited in claim 3. *Compare* Ex-1001, 16:33-35, *with* Ex-1001, 18:26-28. In my opinion, claim 16 is taught or suggested for the reasons discussed for claim 3. *Supra* Section X.A.3.

181. The table below shows the correspondence between the claims.

Claim 3	Claim 16
The computer-implemented method of claim 1, further comprising recalculating at least one of the	The computer-implemented method of claim 15, further comprising recalculating at least one of the

respective routes based on the modified schedule of movement.	respective routes based on the modified schedule of movement.

17. Dependent Claim 17: The computer-implemented method of claim 15, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

182. Claim 17 repeats or recites features that are substantively identical to features recited in claim 4. *Compare* Ex-1001, 16:33-35, *with* Ex-1001, 18:30-33. In my opinion, this limitation is obvious for the same reasons as provided for claim 4. *Supra* Section X.A.4.

183. The table below shows the correspondence between the claims.

Claim 4	Claim 17
The computer-implemented method of claim 1, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.	The computer-implemented method of claim 15, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

18. Dependent Claim 18: The computer-implemented method of claim 17, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and thermoforming an orthodontic aligner over each of the respective positive molds.

184. Claim 18 repeats or recites features that are substantively identical to features recited in claim 5. *Compare* Ex-1001, 16:40-45, *with* Ex-1001, 18:34-39. In

my opinion, claim 18 is obvious for the same reasons provided for claim 5. *Supra* Section X.A.5.

185. The table below shows the correspondence between the claims.

Claim 5	Claim 18
[5(a)] The computer-implemented method of claim 4, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and	[18(a)] The computer-implemented method of claim 17, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and
[5(b)] thermoforming an orthodontic aligner over each respective positive mold.	[18(b)] thermoforming an orthodontic aligner over each of the respective positive molds.

19. Independent Claim 19

186. Claim 19 repeats or recites features that are substantively identical to features recited in claim 8, except for the removal of "by one or more computer processors" in claim 19. *Compare* Ex-1001, 16:58-17:4, *with* Ex-1001, 18:40-52. In my opinion, claim 19 is taught or suggested for the reasons discussed for claim 8. *Supra* Section X.A.8.

187. The table below shows the correspondence between the claims.

Claim 8	Claim 19
[8(a)] The computer-implemented method of claim 1, wherein: the determining of the schedule of movement comprises	[19(a)] The computer-implemented method of claim 15, wherein: the determining of the schedule of movement comprises

determining, by one or more computer processors, a total number of the treatment stages; and	determining a total number of the treatment stages; and
[8(b)] the determining of the total number of the treatment stages comprises: determining, by one or more computer processors, a respective minimum number of treatment stages for each of the dental objects; and	[19(b)] the determining of the total number of the treatment stages comprises: determining, by one or more computer processors, a respective minimum number of treatment stages for each of the dental objects; and
[8(c)] selecting, by one or more computer processors, a largest of the respective minimum numbers of treatment stages as the total number of the treatment stages.	[19(c)] selecting, by one or more computer processors, a largest of the respective minimum numbers of treatment stages as the total number of the treatment stages.

20. Independent Claim 20

a. 20(pre)-20(f)

188. Claim 20 repeats or recites features that are substantively identical to features recited in previous independent claims. For example, limitation 20(pre) is substantively identical to limitation 9(pre), limitations 20(a)-20(c) are substantively identical to limitations 1(a)-1(c), and limitations 20(d)-20(f) are substantively identical to limitations 15(d)-15(f). *Compare* Ex-1001, 17:5-8, 16:11-24, and 18:2-15, *with* Ex-1001, 18:53-19:10. Accordingly, limitations 20(pre)-20(f) are taught or suggested for the reasons discussed in the corresponding portions of claims 1, 9, and

15. *Supra* Sections X.A.1.b-.d [1(a)-1(c)], X.A.9.a [9(pre)], X.A.15.b-.d [15(d)-15(f)].

189. The table below shows the correspondence between the claims.

Limitation 9(pre)	Limitation 20(pre)
[9(pre)] A non-transitory computer-readable medium comprising instructions that, when executed by one or more computer processors, cause at least one of the one or more computer processors to:	[20(pre)] A non-transitory computer-readable medium comprising instructions that, when executed by one or more computer processors, cause at least one of the one or more computer processors to:

Limitations 1(a)-1(c)	Limitations 20(a)-20(c)
[1(a)] determining, by one or more computer processors, a schedule of movement for dental objects during treatment stages, the dental objects being based from output of a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;	[20(a)] determine a schedule of movement for dental objects during treatment stages, the dental objects being based from output from a scanning device, wherein the schedule of movement indicates whether each of the dental objects moves during each of the treatment stages;
[1(b)] calculating, by one or more computer processors, a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and	[20(b)] calculate a respective route from an initial position toward a final position for each of the dental objects during the treatment stages; and
[1(c)] modifying, by one or more computer processors, the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes, the modifying comprising:	[20(c)] modify the schedule of movement to avoid a collision or obstruction between two of the dental objects on their respective routes,

Limitations 15(d)-15(f)	Limitations 20(d)-20(f)
[15(d)] the modifying comprising: determining, by the one or more computer processors, that the respective route of a first of the dental objects results in a collision or obstruction with a second of the dental objects;	[20(d)] the modifying comprising: determining that the respective route of a first of the dental objects results in a collision or obstruction with a second of the dental objects;
[15(e)] altering, by the one or more computer processors in response to the determining, the schedule of movement by delaying initial movement of the first dental object;	[20(e)] altering, in response to the determining, the schedule of movement by delaying initial movement of the first dental object;
[15(f)] determining, by the one or more computer processors, that the altered schedule of movement still results in a collision or obstruction involving the first dental object; and	[20(f)] determining that the altered schedule of movement still results in a collision or obstruction involving the first dental object; and

b. [20(g)] altering, after the determining that the altered schedule of movement still results in a collision or obstruction, the schedule of movement by round-tripping the first dental object.

190. In my opinion, limitation 20(g) is substantively identical to limitation 15(g). While limitation 20(g) uses the term "round-tripping the first dental object," limitation 15(g) uses the agreed construction for the term "round-tripping" in place of that term, and thus the limitations are substantively identical. *Compare* Ex-1001, 18:16-25, *with* Ex-1001, 19:11-14. Accordingly, limitation 20(g) is taught or suggested for the reasons discussed in limitation 15(g). *Supra* Section X.A.15.e.

191. The table below shows the correspondence between the claims.

Limitation 15(g)	Limitation 20(g)
[15(g)] altering, by the one or more computer processors after the determining that the altered schedule of movement still results in a collision or obstruction, the schedule of movement of the first dental object by moving the first dental object out of the path of the second dental object, and once the second dental object has moved sufficiently, moving the first dental object back to the first dental object previous position before proceeding to a desired final position of the first dental object.	[20(g)] altering, after the determining that the altered schedule of movement still results in a collision or obstruction, the schedule of movement by round-tripping the first dental object.

21. Dependent Claim 21: The medium of claim 20, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns.

192. Claim 21 repeats or recites features that are substantively identical to features recited in claim 2, except for the preamble. *Compare* Ex-1001, 16:28-32, *with* Ex-1001, 19:15-18. In my opinion, claim 21 is obvious for the same reasons as provided for claim 2. *Supra* Section X.A.2.

193. The table below shows the correspondence between the claims.

Claim 2	Claim 21
The computer-implemented method of claim 1, wherein determining the schedule of movement comprises selecting a movement pattern from a	The medium of claim 20, wherein determining the schedule of movement comprises selecting a movement pattern from a plurality of predetermined movement patterns.

plurality of predetermined movement patterns.	

22. Dependent Claim 22: The medium of claim 20, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to recalculate at least one of the respective routes based on the modified schedule of movement.

194. Claim 22 repeats or recites features that are substantively identical to features recited in claim 3, except for reciting "wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to …". *Compare* Ex-1001, 16:33-35, *with* Ex-1001, 20:1-5. In my opinion, claim 22 is taught or suggested for the reasons discussed for claim 3. *Supra* Section X.A.3.

195. The table below shows the correspondence between the claims.

Claim 3	Claim 22
The computer-implemented method of claim 1, further comprising recalculating at least one of the respective routes based on the modified schedule of movement.	The medium of claim 20, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to recalculate at least one of the respective routes based on the modified schedule of movement.

23. Dependent Claim 23: The medium of claim 20, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more

computer processors to control manufacture of at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

196. Claim 23 repeats or recites features that are substantively identical to features recited in claim 4, except for reciting "wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to …". *Compare* Ex-1001, 16:36-39, *with* Ex-1001, 20:6-11. In my opinion, claim 23 is obvious for the same reasons as provided for claim 4. *Supra* Section X.A.4.

197. The table below shows the correspondence between the claims.

Claim 4	Claim 23
The computer-implemented method of claim 1, further comprising manufacturing at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.	The medium of claim 20, wherein the instructions, when executed by the one or more computer processors, further cause at least one of the one or more computer processors to control manufacture of at least two orthodontic aligners, each of the orthodontic aligners corresponding to a respective one of the treatment stages.

24. Dependent Claim 24: The medium of claim 23, wherein the manufacture comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and thermoforming a respective one of the

orthodontic aligners over each of the respective positive molds.

198. Claim 24 repeats or recites features that are substantively identical to features recited in claim 5, except for the preamble. *Compare* Ex-1001, 16:40-45, *with* Ex-1001, 20:12-17. In my opinion, claim 24 is obvious for the same reasons provided for claim 5. *Supra* Section X.A.5.

199. The table below shows the correspondence between the claims.

Claim 5	Claim 24
[5(a)] The computer-implemented method of claim 4, wherein the manufacturing comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and	[24(a)] The medium of claim 23, wherein the manufacture comprises: fabricating a respective positive mold of the dental objects for at least two of the treatment stages; and
[5(b)] thermoforming an orthodontic aligner over each respective positive mold.	[24(b)] thermoforming a respective one of the orthodontic aligners over each of the respective positive molds.

XI. Conclusion

200. For the reasons set forth above, in my opinion, a person of ordinary skill in the art would have considered claims 1-24 of the ’879 patent to be obvious over the prior art discussed above.

201. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: April 11, 2025 By: Sumit Yadav

Dr. Sumit Yadav