International Journal of Surgery Case Reports 84 (2021) 105934

Contents lists available at ScienceDirect

International Journal of Surgery Case Reports

journal homepage: www.elsevier.com/locate/ijscr

Case report

Combined orthodontic and orthognathic treatment with 3D-printing technique offers a precise outcome: A case report of two years followup

Xiaolei Hu [a,d,1], Ping Ji [a,b,e,1], Tao Wang [a,b,e,*], Xiaomian Wu [a,b,c,**,1]

[a] Chongqing Key Laboratory of Oral Diseases and Biomedical Sciences, College of Stomatology, Medical University, Chongqing, China
[b] Chongqing Municipal Key Laboratory of Oral Biomedical Engineering of Higher Education, College of Stomatology, Chongqing Medical University, China
[c] Department of Orthodontics, College of Stomatology, Chongqing Medical University, China
[d] Key Laboratory of Clinical Laboratory Science, Ministry of Education, College of Laboratory Medicine, Chongqing Medical University, China
[e] Department of Oral and Maxillofacial Surgery, Stomatological Hospital, The Affiliated Hospital of Stomatology, Chongqing Medical University, China

ARTICLE INFO

Keywords:
Precision medicine
Computer-aided surgical simulation (CASS)
Combined orthodontic and orthognathic treatment (COOT)
3D technique
Surgery first
Case report

ABSTRACT

Introduction and importance: Precision Medicine and evidence-based clinical treatment approach are proposed worldwide in medical science nowadays. Orthodontic first approach (OFA) and Computer-aided surgical simulation (CASS) combined 3D-printing technique offered more chances for the doctors to obey the principle of Precision Medicine in the orthodontic and orthognathic approach.

Case presentation: We reported a 20-year-old patient, with skeletal Class III relationship and asymmetric mandible, was treated by OFA. And with the CASS combined 3D-Printing Technique, the presurgery simulation and 3D-printed surgery guiding splint and stable splint offered the Combined Orthodontic and Orthognathic Treatment (COOT) a powerful and accurate guiding. The results exhibited that the patient had a perfect maxilla and mandible relationship and significant improvement in profile.

Clinical discussion: There is still a debate between "surgery first" (SF) and conventional OFA. In this study, we analyzed the trend of different approaches in the COOT, which was a team work and required mainly the collaboration of orthodontist and Orthognathic surgeon. This study showed the precision of the CASS could offer for the OFA to evoke people immersing in saving time in COOT.

Conclusion: All of these indicated that CASS was a powerful and precise method for COOT, which could offer the patient an esthetic and stable result.

1. Introduction

The success and long term of posttreatment stability was concerned by every clinician. The success and long term of postsurgery stability of Combined Orthodontic and Orthognathic Treatment (COOT) require not only the high quality of pre-surgery and post-surgery orthodontic treatment but also the precision of craniomaxillofacial (CMF) surgery [1]. The computer-aided surgical simulation (CASS) could offer a three-dimensional (3D) composite skull model to accurately represent the CMF skeleton, the dentition and the facial soft tissue for patient [1,2]. All of these information mentioned above are utilized to rebuild an anatomical reference frame to perform orthognathic surgery stimulating. So, CASS is an accurate method to connect the orthodontic treatment and surgery in the COOT.

Nowadays, some technique or approaches were worldwide applied without solid evidence, while about 234 million surgical procedures are undergoing each year [3–5]. "Surgery first" (SF) could save some time in most cases, but the time could not compensate the possibility failure of long term stability. The SF is not so new and novel as most people consider it, and it was first proposed ten years before by Nagasaka et al., which should be careful in selected case [6]. In some countries, SF is considered as new or novel. What's more, in some areas, as least in the Asian region as we know, the SF is encouraged rather than performed only in selected case [7]. However, after longtime clinical observation, the systematic review and meta-analysis showed that compared with SF, the OFA could offer a better long term of postsurgery stability [8]. The

* Correspondence to: T. Wang: Floor 6, No 7, Shangqingshi Road, Yuzhong District, Chongqing 400015, China.
** Correspondence to: X. Wu, Floor 9, No 7, Shangqingshi Road, Yuzhong District, Chongqing 400015, China.
E-mail addresses: taosan@126.com (T. Wang), wuxiaomian@hospital.cqmu.edu.cn (X. Wu).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.ijscr.2021.105934
Received 2 February 2021; Received in revised form 22 April 2021; Accepted 24 April 2021
Available online 30 April 2021

result of COOT could not only play an vital role on the patient's craniofacial function but also on the patient's esthetic and daily life through all their lifetime. Thinking over again the trend in the approach, selection in COOT is extremely urgent.

Presurgical orthodontic decompensation, orthognathic surgery, and postsurgical orthodontic adjustment are the main steps of classic orthodontic-first approach (OFA) for conventional surgical and orthodontic approach. The presurgical stage is a time consumer, and sometimes the decompenstion contains a temporary period of deterioration of the facial profile [7,9]. However, inappropriate dental alignment could limit the optimal skeletal positioning during surgery in SF approach and the other disadvantage of SF make it unable to be the main approach in clinical practice [10]. The CASS is highly accurate and effective in stimulating the orthognathic surgery process. What's more, when the CASS technique combined with 3D printing technology by a rapid prototyping machine, this process will become more powerful. It will not only stimulate the surgery process and predict the surgery outcome, but also produce the surgery splint and the associated appliance to make sure the precision of stimulated surgery in computer could be transferred to the outcome of the patient during the surgery. In this study, we reported a case with the detail of this approach to show the precision of this approach. This case was performed in our hospital, an academic stomatological Hospital and also an affiliated hospital of medical university, and reported in line with the SCARE guideline 2020 [11].

2. Methods and results

2.1. Subject collection, diagnosis and etiology

A 20-year-old college student turned to us for help and complained long face, mandibular prognathism, anterior crossbite. She reported that there is not special about her drug history and psychosocial history. In her pretreatment facial photographs, she showed a concave profile with middle facial depression, increased lower facial height and a significant asymmetry with chin deviating to the left. And considering her father has the same syndrome of concave profile with middle facial depression and cross bite, it indicates that there is a family medical history related to her craniofacial deformity.

The intraoral examination (Fig. 1) showed that she had both anterior crossbites and posterior crossbites on both sides from central incisors to first molar. And both canine and molar showed end-on Class III relationship on both sides with severe lingually inclined lower incisors. Her mandibular dental midline deviated 3 mm to the left while the maxillary dental midline was coincident with the facial midline, with −2.5 mm overjet and −2.0 mm overbite.

The panoramic radiograph presented the impacted third molars. A lateral cephalometric analysis showed the mandibular prognathism and maxillary hypoplasia with a skeletal Class III relationship (ANB -3.1, Wits appraisal, SNA 78.5, SNB 81.6) (Table 1 and Fig. 1C). The mandibular incisors were severe lingually inclined (IMPA 81.3). And the chin overgrowth was obviously.

2.2. Treatment objective

The following objectives were established: (1) dental decompensation, (2) correct anterior and posterior crossbites, (3) establish ClassI-canine and molar relationship, (4) obtain a normal occlusion with normal overjet and overbite, (5) correct the mandibular asymmetry and (6) improve the middle facial depression to achieve an esthetic facial profile.

2.3. Principle of precision medicine in the treatment alternatives

1) SF. SF approach would save time for dental decompensation. However, the natural dental compensation, such as the lingually inclined lower incisors, could disturb the precision of surgery in correcting the Class III skeletal pattern. What's more, SF also required longer time for postsurgical orthodontic adjustment and the patient had to suffer occlusion trauma before the postsurgical orthodontic adjustment finished.
2) OFA. And the CASS could stimulate where the bone should be cut and how much each bone had to move precisely. While the CASS

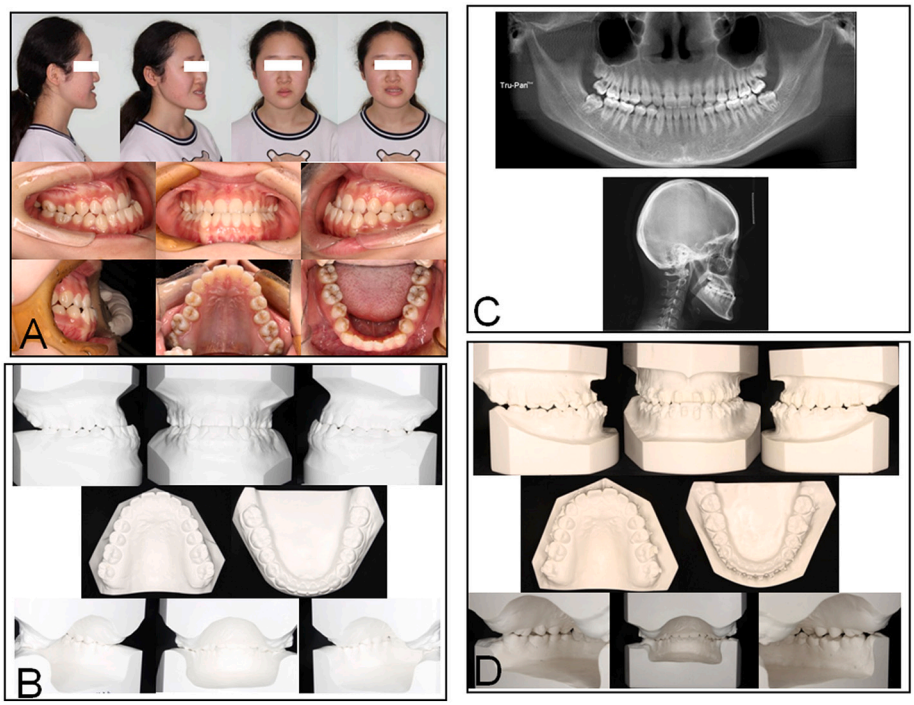

Fig. 1. Presurgery data and Presurgical orthodontic decompensation.
A: Pretreatment photographs. B: Dental Cast of pretreatment. C: Pretreatment radiation examination. D: Dental Case of Presurgery (after presurgical orthodontic decompensation).

Table 1
The pretreatment and posttreatment cephalometric analyses. Cephalomertic analyses of the patient pretreatment and posttreatment was performed with Dolphin Imaging Software.

Measurement	Norm	Pretreatment	Posttreatment
SNA (°)	82.0 ± 3.5	75.4	81.9
SNB (°)	80.9 ± 3.4	79.6	80.5
ANB (°)	1.6 ± 1.5	−4.2	1.4
MP-SN (°)	32.4 ± 4.7	45.8	38.7
MP-FH(°)	23.9 ± 4.5	45.8	24.5
IMPA (°)	95.0 ± 7.0	72.9	82.9
Facial plane to SN(°)	80.5 ± 4.0	80.7	82.6
Facial angle (FH-NPo)(°)	89.0 ± 3.0	95.8	96.8
Occ plane to FH (°)	6.8 ± 5.0	10.0	7.4
Wits appraisal (mm)	−1.0 ± 1.0	−15.1	−6.9
Lower face height (ANS-Gn) (mm)	65.0 ± 4.5	72.9	69.1
Upper face height (N-ANS) (mm)	50.0 ± 2.5	58.3	54.3
U1-L1 (°)	130.0 ± 6.0	143.4	139.3
U1-SN (°)	102.8 ± 5.5	97.8	99.1
U1-NA (mm)	4.3 ± 2.7	6.6	5.5
L1-NB (mm)	4.0 ± 1.8	3.2	4.5
Overjet (mm)	2.5 ± 2.5	−2.9	3.2
Overbite (mm)	2.5 ± 2.0	0.4	1.1
Upper lip to E-plane (mm)	−6-0 ± 2.0	−6.0	−1.3
Lower lip to E-plane (mm)	−2.0 ± 2.0	−1.2	−0.6
Y-Axis (SGn-SN)	67.0 ± 5.5	72.6	70.0

could predict the outcome of the COOT and the presurgical orthodontic decompensation would remove tooth obstruct which will be during surgery and allow the surgery to represent the precise stimulating of CASS.

After consider the advantages and disadvantages of each approach, the patient chose the OFA.

2.4. Principle of precision medicine in the treatment progress

For the presurgical orthodontic decompensation, 0.022 × 0.028-in straight wire brackets were boned to all the teeth. The initial upper and lower archwires were 0.014 NiTi archwires for decompensation and further leveled and aligned followed by 0.016 NiTi, 0.018 NiTi, 0.016 × 0.022 NiTi, 0.018 × 0.025 NiTi, 0.019 × 0.025 NiTi, and 0.019 × 0.025 stainless steel arch wires. When the presurgical orthodontic decompensation was done, the patient's CBCT and cephalometric radiograph, dental cast were taken. After these data were input, the CASS was performed to stimulate the surgery and produce surgery splint and the associated appliance (PTY MEDTEC). After segmentation, reconstruction and measurement, the analyzes of the patient's dentition, occlusion, profile, maxillary and mandibular asymmetry, TMJ, intramandibular course of the mandibular canal, respiratory tract were performed (Fig. 2).

The stimulated plan of the CASS indicated that the LeFort I osteotomy should be used in combination with the bilateral sagittal split osteotomy (BSSO) to correct the crossbites and the asymmetrical mandibular deformities (Fig. 3A, B and C). In brief, referenced to the incisal edge of maxillar central incisor, the maxilla should be moved 3.70 mm foreword and 1.68 mm upward, and referenced to the anterior nasal spin, the maxilla should be moved 3.26 mm foreword and 2.15 mm upward. Referenced to the incisal edge of lower central incisor, the mandible should be moved 2.80 mm backward and 1.04 mm right, and

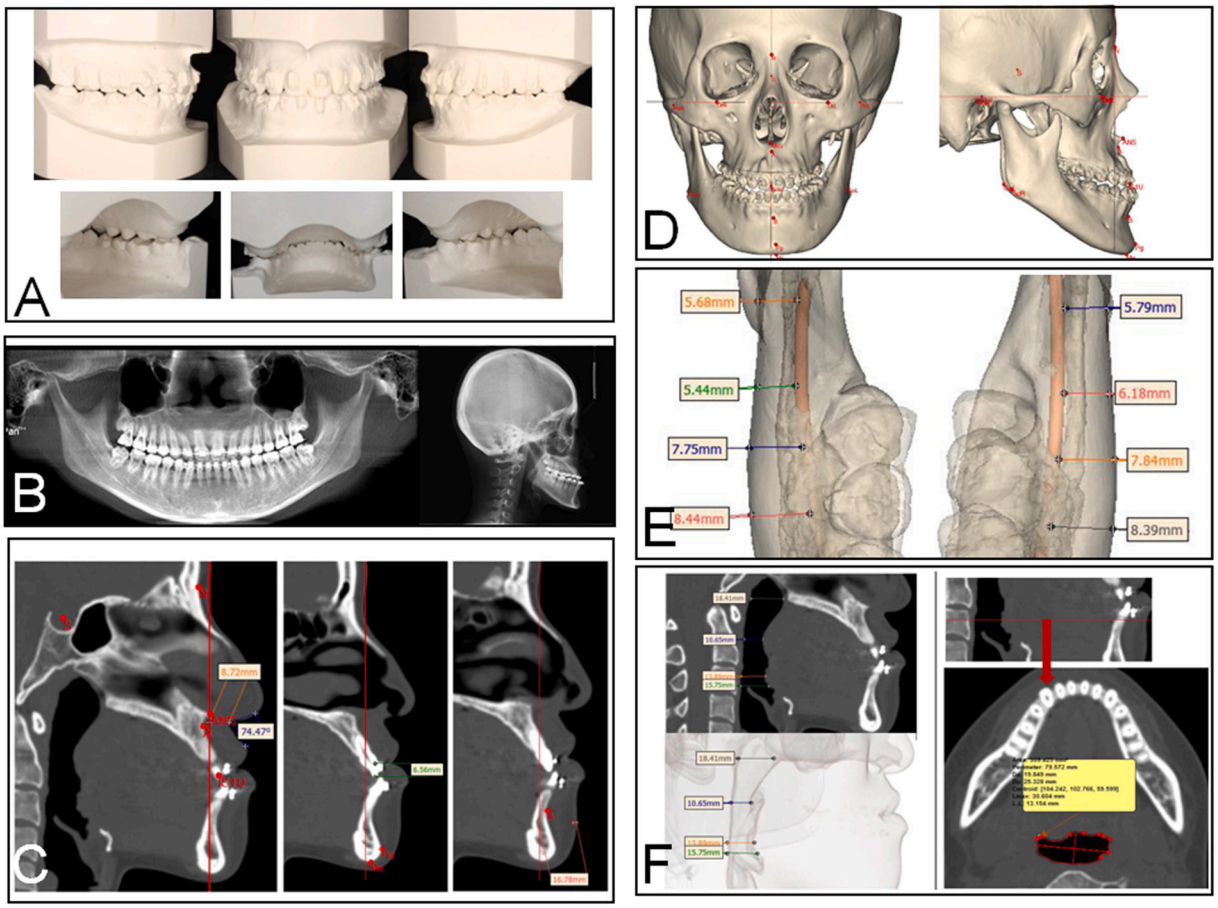

Fig. 2. Data input for Computer-aided surgical simulation (CASS) and analyzes for the patient. A: The simulated maxilla and mandible relationship in dental cast; B: Radiation examination presurgery; C: The skeletal relationship of maxilla and mandible presurgery; D: 3D markers for the maxilla and mandible; E: Location of the mandibular canal; F: Airway.

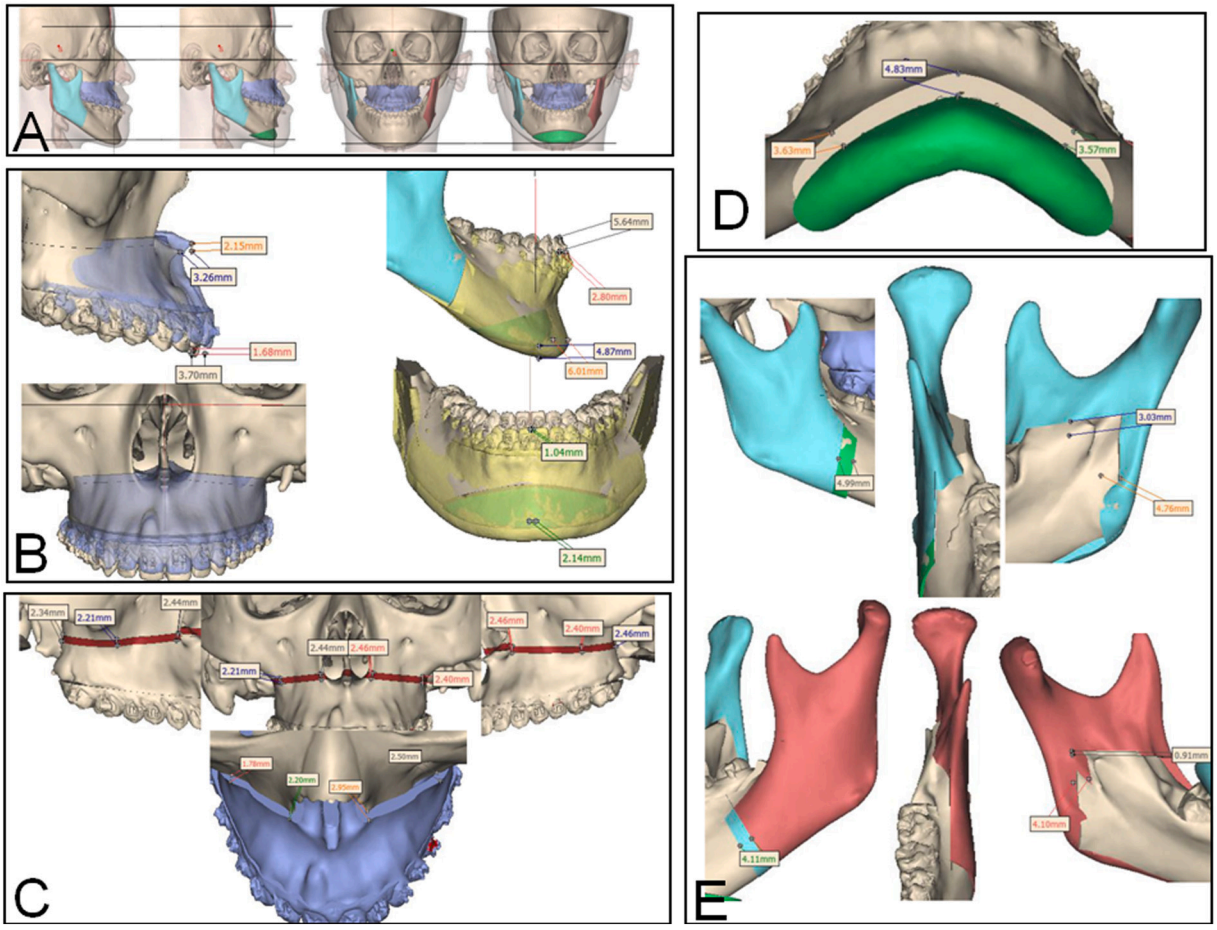

Fig. 3. CASS was performed for the patient. A CASS: a The overview of the osteotomy; b and c The amount of maxilla should be moved in the LeFort I osteotomy to change the occlusive plan; d The amount of chin should be moved in genioplasty; e and f: The amount the mandible should be moved in the bilateral sagittal split osteotomy (BSSO).

referenced to the gnathion, the mandible should be moved 6.01 mm upward and 2.14 mm right (Fig. 3D and E). For the LeFort I osteotomy, the maxillary osteotomy should be 2.44 mm at the edge of right pyriform fossa, 2.46 mm at the edge of light pyriform fossa, 2.21 mm at the right zygomatic process, 2.40 mm at the left zygomatic process, 2.34 mm at the right maxillary tuberosity, 2.46 mm at the left maxillary tuberosity, and 2.66 mm interference at the nasal septum (Fig. 3D and E). For the BSSO, the osteotomy at the right mandibular ramus should be 4.99 mm at anterior, 3.03 mm interference upward and 4.76 mm backward. For the left mandibular ramus, the osteotomy should be 4.11 mm at anterior, 4.10 mm interference upward and 0.91 mm backward. For the genioplasty, chin portion of the jawbone should be moved 4.83 mm backward. After discussed with the patient, she accepted to have the LeFort I osteotomy and BSSO. However, the "Tapered face" is popular among web celebrities, and the patient also preferred to keep her original profile of her chin.

With the simulated data of CASS, the surgery guiding splint, the stable splint and related appliances were produced which could transferred and kept the accuracy of CASS to the surgery and outcome of the treatment (Fig. 4A).

2.5. Postsurgery orthodontic adjustment and follow-up

After orthopedic surgery the patient was in hospital with conventional care and a full liquid diet for three weeks. And the radiation examination was performed to check the outcome of surgery. Then the patient had vertical elastic for one month after surgery and started postsurgery orthodontic adjustment three month after surgery (Fig. 4B). And the follow up was every month for orthodontic treatment. One year after orthopedic surgery the fixed bone-screw materials were removed. And a two years follow-up of posttreatment, it was shown in the Fig. 4D.

2.6. Outcomes measured present the principle of precision medicine

Posttreatment, the radiation was done and the dental model was taken. And the outcomes were measured. After the COOT, all the treatment objectives were achieved. First, the natural dental compensation was corrected. Second, the anterior and posterior crossbites were treated. Third, the ClassIcanine and molar relationship were established and the patient's masticatory efficiency was improved significantly which was reported by the patient. Fourth, a normal occlusion with normal overjet and overbite were obtained. Fifth, the mandibular asymmetry was corrected. After treatment, the centerlines of the upper and lower dentition were coincident with the skeletal centerline.(Fig. 4C and D).Sixth, the middle facial depression was treated. The patient's dish face was disappeared and an esthetic facial profile was achieved (Figs. 4C and D and 5; Table 1).

The comparison of pretreatment and posttreatment lateral cephalometric analysis results showed that the patient's skeletal was significantly changed. The ANB was changed from −4.2 to 1.4 and the MP-FH was changed from 45.8 to 24.5. The patient was satisfied with her profile, smile and the masticatory efficiency obtained by the COOT. And the stability of this result could be found in the photographs of Fig. 5C-b after two years of follow-up.

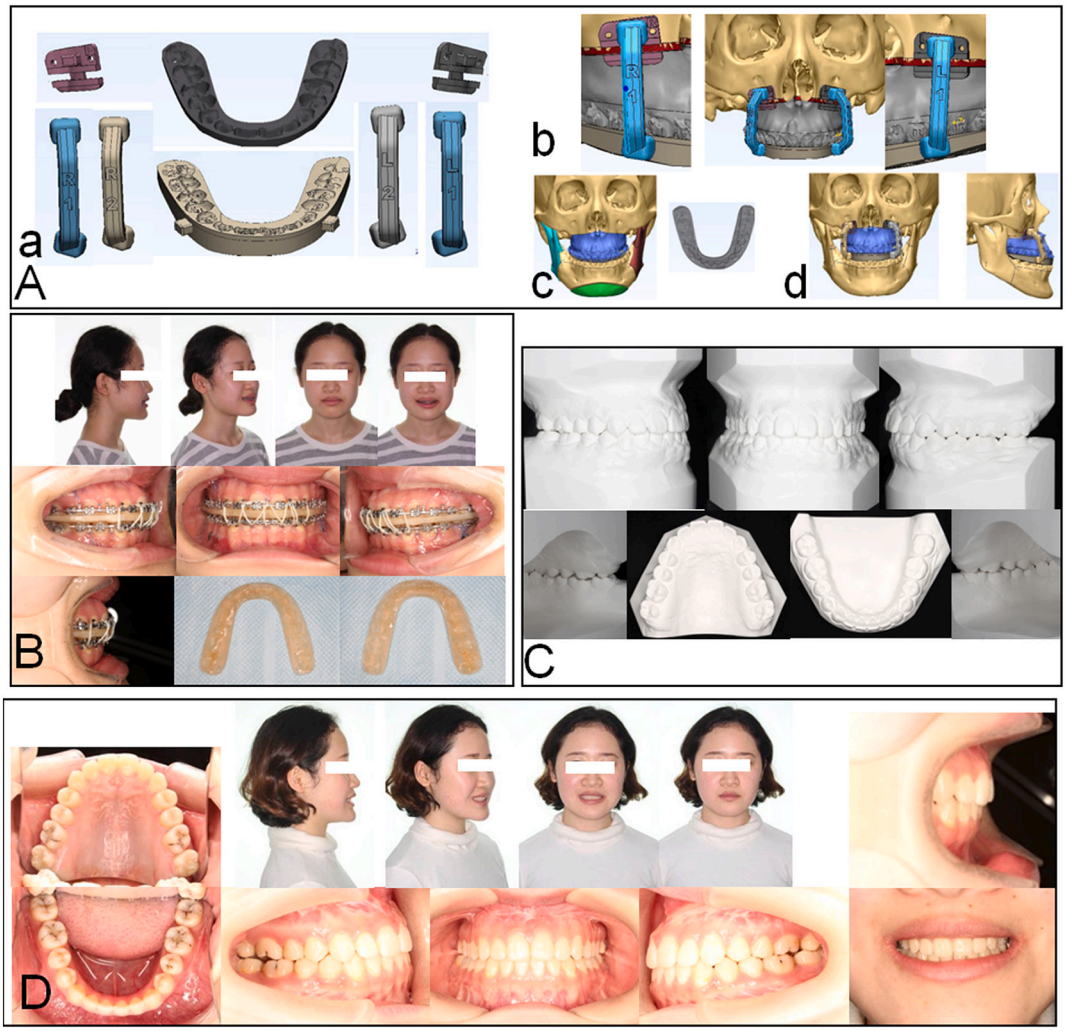

Fig. 4. CASS combined 3D-printing technique for the surgery of the patient. A: With the simulated data of CASS, the 3D-printing technique was able to produce splints and relative appliances (a). The surgery guiding splint (b,c) and relative appliances were utilized during the surgery for fixing and the stable splint (d) was applied post-surgery for vertical elastic. B: Two weeks post-surgery and starting to have vertical elastic for one month. C: Posttreatment Dental cast. D: Posttreatment photographs:One and half years postsurgery.

3. Discussion

There are two approaches in the COOT. One is with the Precision Medicine principle and the help of digital technology to diagnose, design, prepare, treat and finely adjust the subject as accuracy as we can. And on the other hand, the another approach is try to reduce the treatment duration, to decrease the patient's financial and physical suffering and to better the patient's worse profile during pre-surgery orthodontic treatment. However, all of these could not compensate the failure of surgery or long term of posttreatment stability. SF is one of the options and there are other new approaches were creating. For example, the new approach to correct the anteroposterior and transverse maxillary deficiencies in only one-step surgical intervention [12]. We propose that for these cases, the careful selected case and more evidence are required.

Precision Medicine obey the principle of evidence-based clinical treatment approach and have evoked more and more attention among clinicians. Targeting immune checkpoints, immunotherapies have revolutionised oncology and made the Precision Medicine vital and hot recently [13]. In order to change the gap between traditional disease-focused medicine and patients' needs, Precision Medicine is now not only focusing in cancer, but also in the precision care about managing multimorbidity, cardiorenal syndrome, public health, obstructive sleep apnoea and so on [13–17]. The Precision Medicine is supported by lots of countries and even a race among different countries is undergoing. For example, trying to obtain the leadership position in the next 10 years among countries investigating in genomic medicine, the French launches a plan, Genomic Medicine 2025, which would be supported by government and public financing of € 670 million by the year 2020 [18]. In the orthodontic field, orthodontists also considered the evidence more carefully, and the 3D-printing technique is utilized in 3D-printed splint, aligners, bracket and so on [19–20].

While the SF approach could save treatment time, but it still has some disadvantages in the COOT. First, it is difficult to perform elastics postoperatively to counteract muscle traction. In order to have elastics, mini screws had to be implanted or orthodontic brackets should be placed one week before surgery without archwire. While the brackets were places in each tooth to offer the hooks for elastics, it increased the risk of accidental aspiration during surgery. Second, SF might cause occlusal trauma in the period from the time of surgery was completed to the time of alignment was finished. And the unstable occlusion would aggravate the periodontal disease, while the periodontal disease was spread widely world wise in adult [21]. And most of the COOT cases were performed in adult patients. Third, SF approach might induce unnecessary orthodontic pain and discomfort. In order to accelerate the treatment process, orthodontic treatment was conventionally started

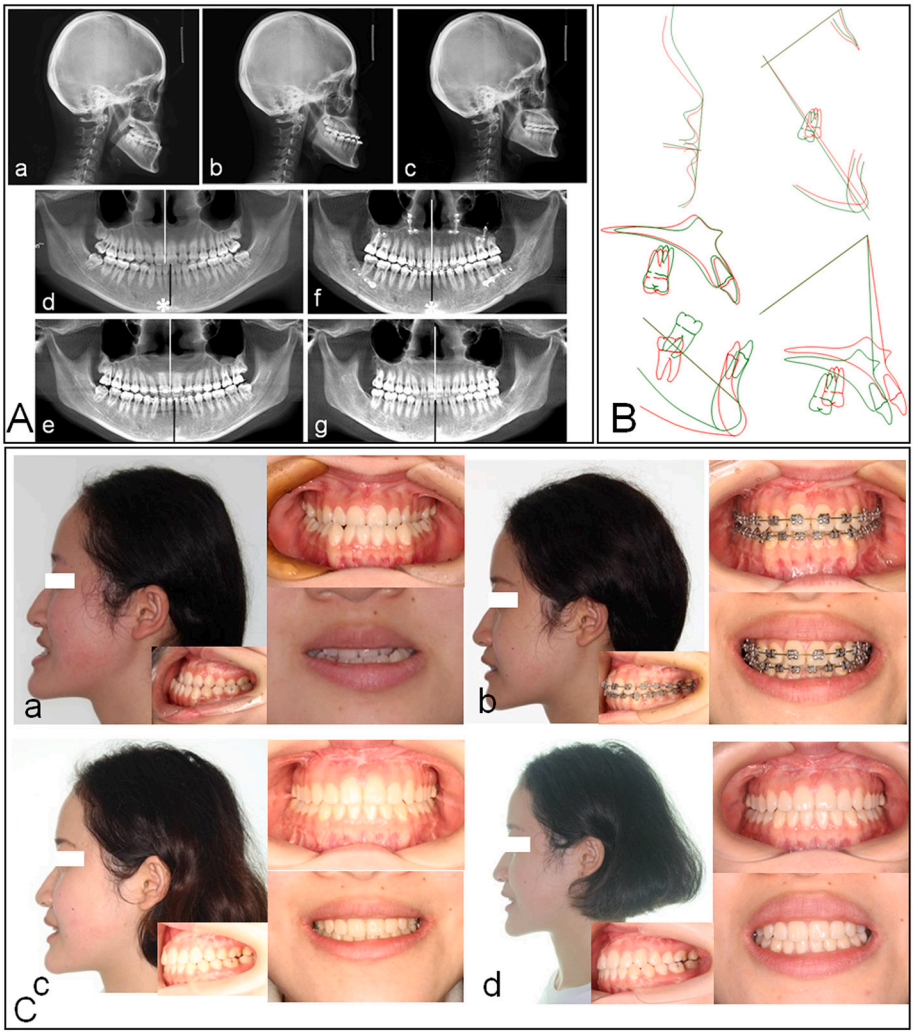

Fig. 5. Comparision in radiation examination. A: The comparison of cophalometric photographs: Pretreatment (a), Presurgery (b) and Posttreatment(c); radiation examination: Pretreatment (d), Presurgery (e), Presurgery (f) and Posttreatment (g) (White line: the centerline of upper dentition and the skeletal centerline; Black line: the centerline of lower dentition). B: Ricketts superimposition. Pretreatment (Green) and Posttreatment (Red). C: The postsurgery stability of COOT combined 3D-printing technique for the surgery of the patient. a: Pretreatment. b: Three months postsurgery. c: One and half years postsurgery. d: Two years following up. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2 weeks postoperatively and orthodontic archwires were changed every second to third week, and patients were persuaded to use of an occlusal splint while eating routinely regarding postoperative stability [6,10]. All of these might add discomfort to patients. In most time, patients was still suffering postoperative pain and swelling 2 weeks after surgery and changing orthodontic archwires every two to three weeks could add orthodontic pain and increase the risk of root absorption, especially when the dentition was too crowding. Fourth, result from clinical meta-analysis showed that compared with conventional orthodontics-first approach, surgery-first/early-orthognathic approach yield poorer post-treatment stability, especially, the mandible tending to rotate counter-clockwise more [8]. So, careful patient selection was proposed of SF, or encouragement for SF as a main approach in daily clinical practice could be a disaster for the patients and also for the doctor around the world.

In this study, the CASS combined 3D-Printing technique exhibited the main principle of Precision Medicine and offered the high level of accuracy for COOT (Figs. 2, 3 and 4). On the one hand, the patient obeyed to the main suggestions of the CASS, and had the BSSO to correct the crossbites and asymmetrical mandibular deformities and had the LeFort I osteotomy to change the occlusive plan (Fig. 4). And she got a normal maxilla and mandible relationship, significantly improved profile and self-confident smile (Figs. 4 and 5). On the other hand, the patient like the "Tapered face" and refused the genioplasty which was suggested by the CASS and our previous plan (Fig. 3D). As a result, her chin was not perfect by our professional view (the Wits Appraisal was changed from −15.1 mm to −6.9 mm)and the genioplasty was need, but she liked it (Figs. 4D and 5C). Both the negative and positive side of the patient's result showed the powerful and precise of the CASS, which could be proposed to be the main approach in COOT around the world (Figs. 2,3,4 and 5). And a long term of follow-up also showed a stable result.

4. Conclusion

1 3D-technique combined OFA and CSSA should be proposed for COOT worldwide.

2 CASS is a powerful and precise method for COOT, which could offer the patient an esthetic and stable result.

Ethical approval

All the conduct in this case report was approved by the Ethical Committee of the Affiliated Hospital of Stomatology, Chongqing Medical University.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Research registration

Name of the registry: not applicable.

Unique identifying number or registration ID: Not applicable.

Hyperlink to your specific registration (must be publicly accessible and will be checked): Not applicable.

Guarantor

Prof. Xiaomian Wu was the Guarantor.

Provenance and peer review

Not commissioned, externally peer-reviewed.

CRediT authorship contribution statement

Dr. Xiaomian Wu and Xiaolei Hu contribute to conceptualization; Dr. Xiaomian Wu performed the presurgical orthodontic decompensation, postsurgery orthodontic adjustment and post orthodontic retaining; And Dr. Tao Wang performed the orthopedic surgery; Dr. Xiaomian Wu, Prof. Xiaolei Hu, Prof. Ping Ji, and Prof. Tao Wang contribute to the plan, project administration and supervision; Dr. Xiaomian Wu, Xiaolei Hu, Prof. Ping Ji, and Prof. Tao Wang contribute to original draft writing, review and editing.

Declaration of competing interest

The authors declare that there is not any conflict of interest among authors.

Acknowledgments

Our study was supported by Overseas Returnees Innovation and Entrepreneurship Support Program of Chongqing (cx2019095), Natural Science Foundation of Chongqing, China (cstc2020jcyj-msxmX0321) and the National Natural Science Foundation of China (31400808) to Xiaomian Wu. This study was also supported by the National Natural Science Foundation of China 21402018 to Xiaolei Hu, 81570979 to Feng Deng and 31871464 to Ping Ji. And we appreciate the patient reported in this article to share the process and result of her case.

References

[1] J.J. Xia, J. Gateno, J.F. Teichgraeber, et al., Algorithm for planning a double-jaw orthognathic surgery using a computer-aided surgical simulation (CASS) protocol. Part 1: planning sequence, Int. J. Oral Maxillofac. Surg. 44 (12) (2015) 1431–1440.

[2] N. Motohashi, T. Kuroda, A 3D computer-aided design system applied to diagnosis and treatment planning in orthodontics and orthognathic surgery, Eur. J. Orthod. 21 (3) (1999) 263–274.

[3] M.J. Speakman, J.-N. Cornu, M. Gacci, et al., What is the required certainty of evidence for the implementation of novel techniques for the treatment of benign prostatic obstruction? Eur. Urol. Focus (2019).

[4] A.D. Shearman, C.P. Shearman, Evidence-based surgery, Surgery (Oxford) 36 (9) (2018) 448–453.

[5] N. Jetté, J.W. Sander, M.R. Keezer, Surgical treatment for epilepsy: the potential gap between evidence and practice, Lancet Neurol. 15 (9) (2016) 982–994.

[6] Hiroshi Nagasaka, Junji Sugawara, Hiroshi Kawamura, et al., "Surgery first" skeletal class III correction using the skeletal Anchorage system, J. Clin. Orthod. 43 (2) (March 2009) 97–105.

[7] H.-S. Hwang, M.-H. Oh, H.-K. Oh, et al., Surgery-first approach in correcting skeletal class III malocclusion with mandibular asymmetry, Am. J. Orthod. Dentofac. Orthop. 152 (2) (2017) 255–267.

[8] H. Wei, Z. Liu, J. Zang, et al., Surgery-first/early-orthognathic approach may yield poorer postoperative stability than conventional orthodontics-first approach: a systematic review and meta-analysis, Oral Surg Oral Med Oral Pathol Oral Radiol 126 (2) (2018) 107–116.

[9] X. He, J. He, H. Yuan, et al., Surgery-first and orthodontic-first approaches produce similar patterns of condylar displacement and remodeling in patients with skeletal class III malocclusion, J. Oral Maxillofac. Surg. (2019).

[10] F. Hernández-Alfaro, R. Guijarro-Martínez, M.A. Peiró-Guijarro, Surgery first in orthognathic surgery: what have we learned? A comprehensive workflow based on 45 consecutive cases, J. Oral Maxillofac. Surg. 72 (2) (2014) 376–390.

[11] R.A. Agha, T. Franchi, C. Sohrabi, G. Mathew, A. Kerwan, The SCARE 2020 guideline: updating consensus Surgical CAse REport (SCARE) guidelines, Int. J. Surg. (London, England) 84 (2020) 226–230, https://doi.org/10.1016/j.ijsu.2020.10.034.

[12] M.D. Pereira, V. Farfel, G.P.R. Prado, et al., One-step surgical correction of transverse and anteroposterior maxillary deficiencies using wire fixation. A new approach and long-term stability, J. Oral Maxillofac. Surg. 75 (7) (2017) 1498–1513.

[13] S. Ogino, M. Giannakis, Immunoscore for (colorectal) cancer precision medicine, Lancet 391 (10135) (2018) 2084–2086.

[14] A.S. Bierman, M.E. Tinetti, Precision medicine to precision care: managing multimorbidity, Lancet 388 (10061) (2016) 2721–2723.

[15] M.L. Wilson, K.A. Fleming, M.A. Kuti, et al., Access to pathology and laboratory medicine services: a crucial gap, Lancet 391 (10133) (2018) 1927–1938.

[16] M.A. Martinez-Garcia, F. Campos-Rodriguez, F. Barbé, et al., Precision medicine in obstructive sleep apnoea, Lancet Respir. Med. 7 (5) (2019) 456–464.

[17] N. Wettersten, A.S. Maisel, D.N. Cruz, Toward precision medicine in the cardiorenal syndrome, Adv. Chronic Kidney Dis. 25 (5) (2018) 418–424.

[18] Y. Lévy, Genomic medicine 2025: France in the race for precision medicine, Lancet 388 (10062) (2016) 2872.

[19] M. Katchooi, B. Cohanim, S. Tai, et al., Effect of supplemental vibration on orthodontic treatment with aligners: a randomized trial, Am. J. Orthod. Dentofac. Orthop. 153 (3) (2018) 336–346.

[20] M.G. Awad, S. Ellouze, S. Ashley, et al., Accuracy of digital predictions with CAD/CAM labial and lingual appliances: a retrospective cohort study, Semin. Orthod. 24 (4) (2018) 393–406.

[21] Kassebaum NJ, Smith AGC, etal. Collaborators GBDOH: Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990–2015: a systematic analysis for the global burden of diseases, injuries, and risk factors. J. Dent. Res. 2017 Apr, 96(4):380–387.