Skeletal and dental responses to orthognathic surgical treatment

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Orthognathic surgical intervention in the treatment of major skeletal and dental deformities has become an accepted procedure over the last two decades. The option of combining orthodontics and surgery has made it possible to treat skeletal and dental dysplasias that are out of the realm of orthodontic therapy alone. The potential for skeletal relapse, however, is a major concern. Various sources of skeletal relapse following orthognathic surgery have been widely reported in the literature. When the mandible is surgically lengthened or shortened, control of the operated segments is of prime importance in preventing postsurgical relapse. Condylar displacement at the time of surgery has been found by some investigators to be a major factor in regression following mandibular advancement.[1-18] An investigation by Will,[19] however, determined that condylar distraction was only a minor factor in relapse, while distal fragment movement accounted for 37% of the relapse of mandibular advancements. Relapse of the distal segment appears to be significantly correlated with the degree of anteroposterior rotation of the proximal segment at surgery.[1,2,4,7,11,15,19-25] According to some investigations, the amount of mandibular advancement appears to bear a direct relationship to the amount of relapse.[1,3,11,13,15,23,24-30] Other

Abstract

This retrospective cephalometric study analyzed dental changes that occurred postsurgically in relation to skeletal stability or instability in a group of 18 orthognathic surgical patients. All surgeries were accomplished in the mandible. In addition, the amount of tooth movement required to complete treatment from surgery to deband and the amount of postsurgical skeletal change was compared between subgroups of skeletal Class II and Class III patients. Also, presurgical skeletal and dental changes were correlated with changes postsurgically. In the entire sample, patients who experienced postsurgical stability in SNB angle required significantly more mandibular incisor linear repositioning than those who experienced instability. Also, patients who experienced instability in anterior facial height required significantly more upper and lower incisor angular repositioning than those who experienced stability. No significant differences could be found when comparing the amount of tooth movement from surgery to deband for the subgroup of skeletal Class II and Class III patients. The Class III patients exhibited more change in mandibular plane postsurgically than the Class II patients. No significant correlations were found between presurgical and postsurgical changes in skeletal and dental parameters in the entire sample.

Key Words

Orthognathic surgery • Tooth movement • Skeletal changes • Dental changes

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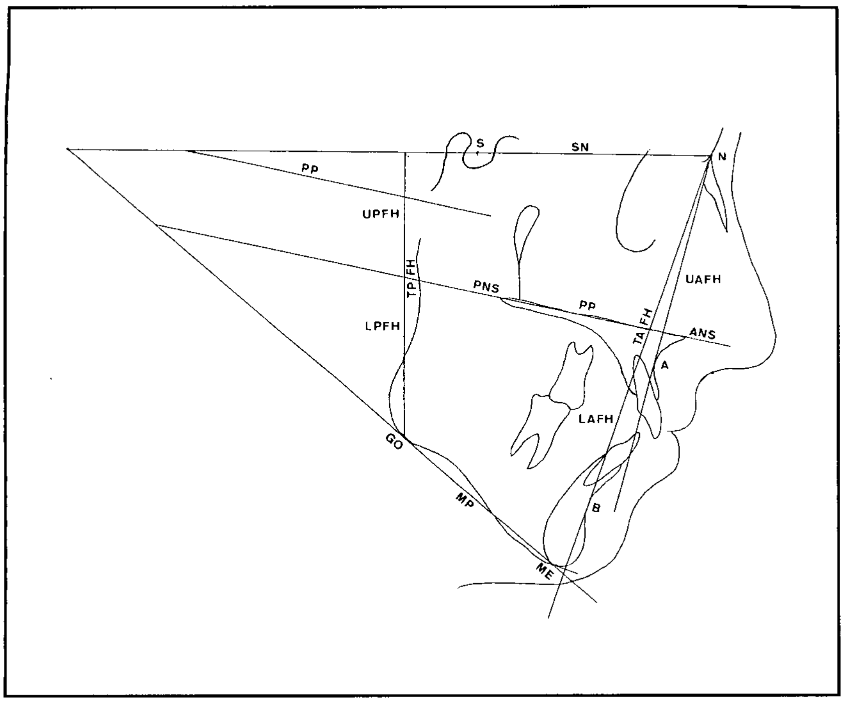

Figure 1
Sample headfilm tracing showing points, planes, angles, and distances chosen for skeletal measurements.

studies do not support such strong correlations,[6,12,22,31,32] while still others, using rigid fixation techniques, find no difference.[3,20,33,34] It has also been reported that mandibular advancement seems to have a greater relapse potential than setbacks.[4,26,35]

Coupled with the amount of skeletal change that could occur following surgical intervention is the degree of tooth movement required to complete treatment. It would seem that if the skeletal structures remain stable after surgery, minimal tooth movement would be needed to satisfy the treatment plan. This is certainly open to conjecture because very few studies have been undertaken to specifically address this issue. Tooth movement has been reported during the time of intermaxillary fixation.[13,26-29,31,36] Also, changes of tooth position in relation to skeletal postsurgical relapse has been mentioned in numerous studies.[3,8,11,13,22,24,28-30,34,37-44] However, a search of this literature revealed that no attempt has been made to explore the relationship between the amount of postsurgical skeletal change and the amount of tooth movement necessary to complete orthodontic treatment.

One of the first investigations to compare dental changes in patients having rigid vs. nonrigid fixation was reported by Thomas[42] in 1986. This study analyzed mandibular advancement cases and showed that more dental compensation occurred after splint removal in the nonrigid group than in the rigid group. A supporting conclusion was offered in a recent study by Watzke,[34] who found that rigid fixation resulted in minimal tooth movement during a 6-week postsurgical interval. Proffit[45] found no correlation between the amount of presurgical incisor movement and postsurgical skeletal relapse. This was a cephalometric comparison of 61 patients who had superior repositioning of the maxilla as the only surgical procedure.

The present study was designed to answer five specific questions concerning the response of some skeletal and dental parameters to orthognathic surgical treatment among a group of 8 Class II and 10 Class III patients.

1. If the skeletal structures that were moved surgically do not remain stable, was an increased amount of tooth movement required to complete treatment for both the Class II and Class III patients?
2. Was significantly more tooth movement required after surgery to complete treatment for the subgroup of skeletal Class II cases?
3. Which subgroup exhibited more postsurgical skeletal movement?
4. Is there a relationship between the amount of presurgical change in skeletal structures and the amount of skeletal movement postsurgically?
5. Is there a relationship between the amount of tooth movement needed presurgically and tooth change postsurgically?

Materials and method

The sample comprised 18 cases from the principal author's files. All cases were treated by the same orthodontist using an .018x.025 edgewise appliance. Two oral and maxillofacial surgeons treated the patients to the same standard of contemporary surgical technique. Presurgical study casts were mounted for splint construction, providing a path of closure from centric relation to centric occlusion as near as possible to the hinge axis rotation. Splints were constructed as thin as practical for the particular kind of surgery.

The sample included 6 males and 12 females, ranging in age at the beginning of record collection from 15 years 6 months to 42 years 7 months, with a mean age of 24 years 5 months. At the completion of treatment, the age range was 17 years 7 months to 45 years 1 month, with a mean age of 26 years 3 months. Eight of the cases were classified as skeletal Class II and 10 were Class III. The 8 Class II cases comprised 1 male and 7 females and the 10 Class

IIIs comprised 5 males and 5 females. All cases were treated without extraction and all surgeries were performed in the mandible only. The skeletal Class II cases were resolved surgically by lengthening the mandible; in the Class III cases, the mandibles were shortened. None of the patients required chin revision at the completion of treatment.

There were five criteria for case selection:

1. All patients had a diagnosis indicating the need for an orthognathic surgical approach to treatment.
2. Standardized lateral radiographs of adequate quality and resolution available, taken just prior to the start of orthodontic care (T1), within 1 month before surgical intervention (T2), within 1 month after surgical intervention (T3), and within 1 month following the completion of orthodontic care (T4).
3. Cephalometric superimposition on posterior cranial outlines and on point articulare demonstrating that growth did not occur during the postsurgical evaluation period.
4. Surgery involving the tempromandibular joints neither indicated nor performed at any time during the treatment period.
5. Orthodontic treatment to prepare the case for surgery and complete the occlusal correction.

Each radiograph was traced twice; the points chosen for measurement were plotted and the average taken if a discrepancy of more than 1° or 1 mm existed. This was done in order to reduce the error of measurement. The identification of skeletal landmarks creates special problems after surgery. Remodeling may result in the alteration of some landmarks. In this regard, great care was exercised when interpreting the landmarks chosen for assessment, and the authors consider them to be reliable. Definitions of the landmarks have been well documented and need not be included here. The skeletal and dental measurements chosen for analysis and their descriptions include:

Skeletal measurements (Figure 1)

MP-SN: mandibular plane to sella nasion plane (angle in degrees);

SNA: sella, nasion, A-point (angle in degrees);

SNB: sella, nasion, B-point (angle in degrees);

ANB: A-point, nasion, B-point (angle in degrees);

TAFH (total anterior face height): menton to nasion (distance in mm);

LAFH (lower anterior face height): menton to palatal plane (distance in mm);

UAFH (upper anterior face height): palatal plane to nasion (distance in mm);

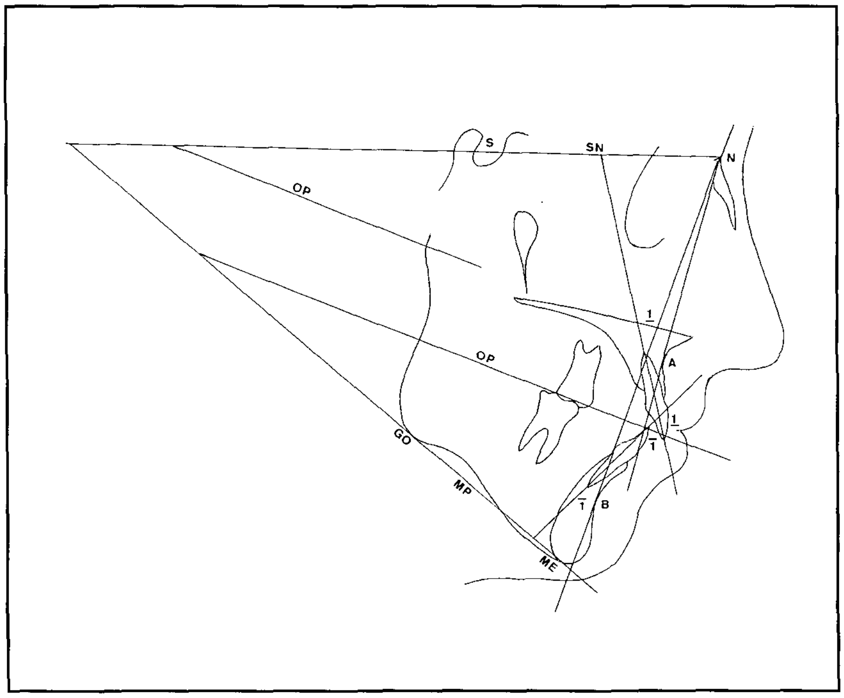

Figure 2

TPFH (total posterior face height): gonion to SN plane (distance in mm);

LPFH (lower posterior face height): gonion to palatal plane (distance in mm);

UPFH (upper posterior face height): palatal plane to SN plane (distance in mm);

PP-MP: palatal plane to mandibular plane (angle in degrees);

PP-SN: palatal plane to sella nasion plane (angle in degrees).

Dental measurements (Figure 2)

$\underline{1}$ – $\overline{1}$: maxillary incisor to mandibular incisor (angle in degrees);

$\underline{1}$ – NA: maxillary incisor to nasion-A-point (angle in degrees);

$\underline{1}$ – NA: maxillary incisor labial surface to nasion A-point (distance in mm);

$\overline{1}$ – NB: mandibular incisor to nasion-B-point (angle in degrees);

$\overline{1}$ – NB: mandibular incisor labial surface to nasion-B-point (distance in mm);

$\overline{1}$ – MP: mandibular incisor to mandibular plane (angle in degrees);

OP – MP: occlusal plane to mandibular plane (angle in degrees);

OP – MP: occlusal plane to sella-nasion plane (angle in degrees);

$\underline{1}$ – SN: maxillary incisor tip to sella-nasion plane (distance in mm);

$\overline{1}$ – MP: mandibular incisor tip to mandibular plane (distance in mm);

$\underline{1}$ – SN: maxillary incisor to sella-nasion plane (angle in degrees).

Figure 2
Sample headfilm tracing showing points, planes, angles and distances chosen for dental measurements.

Table 1
Postsurgical dental movements compared in patients exhibiting postsurgical skeletal stability and instability

Skeletal Parameter	Dental parameter	Skeletal Movement Stable N	Stable Mean	Stable SD	Unstable N	Unstable Mean	Unstable SD
SNB **	$\overline{1}$ – NB (mm)	14	1.00	0.55	4	0.00	0.00
TAFH **	$\overline{1}$ – MP (°)	9	1.89	0.93	9	3.67	1.32
TAFH **	$\underline{1}$ – SN (°)	9	1.22	1.09	9	3.56	1.81
TAFH *	$\underline{1}$ – NA (°)	9	1.33	1.32	9	2.89	2.15
LAFH *	$\overline{1}$ – NB (°)	6	1.33	1.86	12	2.08	0.67
LPFH *	$\underline{1}$ – SN (mm)	4	0.25	0.50	14	1.21	0.70

* $p < .05$; ** $p < .01$; Mann-Whitney test for equal means

Statistical method

A significant change of any skeletal or dental parameter was defined as ±2° or ±2 mm. This change has traditionally been considered outside any random error inherent in the tracing method.

The total sample of 18 subjects was divided into two groups based on a significant change in any of the 12 skeletal parameters. The subjects whose skeletal change from postsurgery to deband was at least ±2° or ±2 mm comprised one group, while the subjects who did not experience this significant change formed the other. The Mann-Whitney test was used to compare tooth movement between the two groups for each of the 12 skeletal parameters and for each of the 11 dental parameters. These tests were used instead of the pooled *t*-test or the separate variance *t*-test because the tooth movement data were often somewhat skewed. Because so many tests were performed, declaring significance at the .05 level risked too many false rejections. Instead, these were considered to approach significance while the tests that were significant at the .01 level were declared significant.

The Mann-Whitney test was also used to compare the group of 8 Class II subjects and the group of 10 Class III subjects with respect to both postsurgical skeletal and dental changes. The relationship between presurgical changes and postsurgical changes was investigated using Spearman's correlation coefficients. These correlations were computed for both skeletal and dental parameters.

Results

Results of this investigation were obtained using the statistical package SAS. Table 1 shows a comparison of the amount of tooth movement between the group of patients who experienced skeletal stability and the group of patients who did not experience skeletal stability. The symbols * and ** indicate significant differences in the means of the two groups at the .05 and .01 levels of significance, respectively, using the Mann-Whitney test. In this part of the study, only the difference in the mean amount of tooth movement for the stable and unstable groups was compared. Both groups sometimes exhibited a large amount of tooth movement but the difference between the groups was found to be insignificant. When viewing this table it should be noted that there were three highly significant situations. The 14 subjects who experienced stability in SNB angle had significantly more change in the mandibular incisor linear position than the 4 subjects who experienced instability. The 9 subjects who experienced stability in total anterior facial height had significantly less change in the mandibular incisor angular position than the 9 subjects who experienced instability. The 9 subjects who experienced stability in total anterior facial height had significantly less change in maxillary incisor angular position than the 9 subjects who experienced instability.

The information in Table 1 relates to those cases where the means were different at the .05 level of significance. Due to the large number of tests performed, these results should be considered as approaching significance only. For the skeletal parameter TAFH, the more stable group of 9 subjects experienced less angular movement of the maxillary incisor than the 9 subjects who did not remain stable. For the skeletal parameter LAFH, the more stable group of 6 subjects experienced less angular movement of the lower incisor than the 12 subjects who did not remain stable. Finally, for the skeletal parameter LPFH, the unstable group of 14 subjects experienced more mean linear change of the maxillary incisor than the 4 subjects who remained stable.

Table 2 shows the comparison of the amount of tooth movement from surgery to the completion of treatment for the subdivided sample of Class II and Class III subjects. No significant differences were found between these two groups.

The comparison of skeletal Class II and Class III postsurgical change is shown in Table 3. In two situations, changes were observed at the .05 level of significance. The Class III subjects showed more change in mandibular plane relative to SN plane and mandibular plane relative to palatal plane than the Class II subjects.

To compare the amount of presurgical skeletal and dental changes with the amount of postsurgical change, Spearman's correlation coefficients were computed. These are shown in Table 4. Presurgical change was not significantly correlated with postsurgical change for any of the 12 skeletal or 11 dental parameters.

Table 2
Postsurgical change (T4 -T3) in skeletal Class II and Class III cases

Dental parameter	Class II (N=8) Mean	SD	Class III (N=10) Mean	SD
$\underline{1}$ – $\overline{1}$ (°)	1.88	1.64	1.80	1.03
$\underline{1}$ – NA (°)	1.62	1.41	2.50	2.22
$\underline{1}$ – NA (mm)	0.88	0.64	0.90	0.88
$\overline{1}$ – NB (°)	2.00	0.67	1.62	1.69
$\overline{1}$ – NB (mm)	0.75	0.71	0.80	0.63
$\overline{1}$ – MP (°)	2.25	1.49	3.20	1.32
OP – MP (°)	1.25	0.89	1.00	1.05
OP – SN (°)	1.62	1.77	1.20	0.63
$\underline{1}$ – NA (mm)	0.88	0.83	1.10	0.74
$\overline{1}$ – MP (mm)	0.88	0.83	0.80	0.79
$\underline{1}$ – SN (°)	1.75	1.49	2.90	2.08

Table 3
Postsurgical change (T4 -T3) in skeletal Class II and Class III cases

Skeletal parameter	Class II (N=8) Mean	SD	Class III (N=10) Mean	SD
MP-SN *	0.88	0.35	1.90	1.10
SNA	0.88	0.84	1.20	0.92
SNB	0.88	0.64	0.80	1.14
ANB	0.50	0.53	0.80	0.79
TAFH	2.00	1.60	1.90	1.10
LAFH	1.50	1.07	2.40	1.17
UAFH	1.00	0.93	1.50	1.18
TPFH	2.25	1.39	2.50	1.84
LPFH	2.00	0.93	2.30	1.77
UPFH	0.75	0.71	1.00	1.16
PP-MP *	0.38	0.74	2.00	1.49
PP-SN	0.62	0.74	1.50	1.65

* $p < .05$ Mann-Whitney test for equal means (none significant)

Discussion

As in other studies of this nature, extreme variability in both tooth and skeletal responses to orthognathic surgical treatment was encountered. Large numbers of changing variables means results must be interpreted with extreme caution. Support can be found for Douma's[3] statement, "Although the occurrence of dental changes has been reported to compensate for postsurgical skeletal changes, such conclusions should be made with caution because of the large individual variability." In this regard, it is obvious that there were age differences, gender differences, and differences in surgical method. These differences were not isolated and examined separately. The study was not designed to compare responses based on these variables or on the method of fixation. It was designed instead to measure the need for an increased amount of tooth movement in response to a significant change in skeletal position from surgery to the completion of treatment.

Among the cases selected for assessment, 8 had rigid fixation and 10 had intermaxillary fixation with interosseous wiring. They were treated at a time of surgical transition from one discipline to the other. It might be interesting to compare a sample of cases in which rigid fixation was used exclusively as the surgical

Table 4
Presurgical and postsurgical change, T2-T1 vs T4-T3
Spearman's correlation ρ_s

Skeletal parameter	ρ_s	Dental parameter	ρ_s
MP-SN	-0.068	$\underline{1}$ – $\overline{1}$ (°)	-0.006
SNA	0.001	$\underline{1}$ – NA (°)	0.243
SNB	-0.210	$\underline{1}$ – NA (mm)	0.136
ANB	0.349	$\overline{1}$ – NB (°)	-0.304
TAFH	0.196	$\overline{1}$ – NB (mm)	0.152
LAFH	0.267	$\overline{1}$ – MP (°)	0.064
UAFH	-0.156	OP – MP (°)	0.026
TPFH	0.444	OP – SN (°)	0.020
LPFH	0.081	$\underline{1}$ – SN (mm)	-0.022
UPFH	-0.278	$\overline{1}$ – MP (mm)	-0.181
PP-MP	0.022	$\underline{1}$ – SN (°)	-0.112
PP-SN	-0.039		

No significant correlations at the 5% level of significance

method. The results may differ in spite of the fact that in the present study, B-point remained stable in 14 of the 18 patients analyzed.

Changes in incisor position from postsurgery to deband have not been well documented. Most studies tend to ignore the amount of tooth movement necessary to complete orthodontic care. Prior to 1986, dental changes in patients having rigid fixation for mandibular advancement were not reported. From that time to the present, only vague references and opinions have been offered when analyzing postsurgical dental responses. For example, Harsha[46] stated, "Improved stabilization at osteotomy site should decrease skeletal shifts and, therefore, decrease dental compensations." Watzke[34] wrote, "It is apparent that it is possible to compensate for skeletal relapse with postsurgical orthodontic treatment." Turvey[43] stated, "Postsurgical orthodontics offers an opportunity to compensate tooth positions for changes in skeletal positions," and Goz[39] offered, "The behavior of the anterior teeth can be correlated with skeletal relapse." The specifics of any of these statements along with relative comparisons were not undertaken. The only study that resembles the current investigation was by Brammer,[1] who analyzed tooth movement and its relation to postoperative skeletal change in 12 patients, 4 of whom had no orthodontic care.

A significant amount of vertical anterior skeletal change occurred between surgery and deband. It would appear that a change in anterior face height postsurgically resulted in the need for an increased amount of incisor movement. This would seem logical because the change in skeletal position lies close to the tooth positions that need to be altered. Of much more interest is the finding that a significant amount of incisor movement was required, even though SNB angle remained stable postsurgically. Therefore, it cannot be concluded that minimal tooth corrections would be needed when this skeletal parameter remains stable following surgical intervention.

Table 1 also shows that there were other responses that approached significance when face height changes were compared with tooth movement. An increase in the angular movement of maxillary and mandibular incisors was needed postsurgically when anterior face height was unstable. Similarly, minimal vertical maxillary incisor movement occurred when the lower posterior face height remained stable.

Although an effort was made to determine if there were differences between the amount of tooth movement from surgery to deband for skeletal Class II and Class III cases, the tests to examine this revealed no significant differences. Therefore, it cannot be concluded from the sample studied that mandibular advancement surgery would require more tooth movement than mandibular setback procedures to complete the occlusal correction.

The data strongly suggest that the Class III subjects experienced more change in mandibular plane angle between surgery and deband than the Class II subjects. No other significant differences in skeletal movement were found postsurgically between these groups, including change in SNB angle. No support can be found for those studies showing that mandibular advancement surgery generates more relapse potential than mandibular setbacks.[4,26,35]

The amount of skeletal or dental movement prior to surgery was not significantly correlated with changes postsurgically. Although long-term stability was not a part of this study, neither skeletal nor dental change due to alterations that occurred prior to surgical intervention were encountered. This finding supports the studies of Proffit[45] and Kohn,[9] both of whom found no significant differences in relapse tendency between orthodontic preparation and no orthodontic preparation prior to surgery.

Conclusions

A cephalometric analysis was made of 18 orthognathic surgical patients, 6 males and 12 females, ranging in age from 15 years 6 months to 42 years 7 months. Radiographs were obtained at four time periods: just prior to the start of orthodontic care, within 1 month before surgery, within 1 month following surgery, and within 1 month following the completion of orthodontic therapy. Twelve skeletal and 11 dental measurements were chosen for analysis. These parameters were subjected to statistical analysis in an effort to determine if a relationship existed between changes in skeletal position postsurgically and the amount of tooth movement required for case completion. A comparison of the amount of tooth movement that was needed from surgery to deband was made between subsamples of skeletal Class II and Class III cases. An analysis was conducted to determine the relationship between skeletal Class II and Class III postsurgical change. Presurgical vs. postsurgical dental and skeletal changes were also compared among all 18 patients.

Results of this study led to the following conclusions:

1a. More mandibular incisor linear movement was needed to complete orthodontic treatment in those patients who experienced stability in SNB angle than in those who experienced instability in SNB angle.

1b. More maxillary and mandibular incisor angular movement was needed to complete orthodontic treatment in those patients who experienced instability in anterior facial height than in those who experienced stability in anterior facial height.

2. No significant difference could be found when comparing the amount of tooth movement from surgery to deband for subsamples of skeletal Class II and Class III patients.

3. Skeletal Class III patients demonstrated more change in mandibular plane angle postsurgically than the skeletal Class II patients.

4. The amount of change presurgically was not significantly correlated with the amount of change postsurgically for any of the skeletal or dental measurements.

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