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Comparative evaluation of the mandibular distraction zone using ultrasonography and conventional radiography

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Abstract. The purpose of this study was to determine the efficacy of ultrasonography (USG) for the evaluation of bone formation in the mandibular distraction wound and to compare this with radiographic evaluation, which is currently the standard modality. Twenty-two patients underwent mandibular distraction (30 sides) with a variety of distraction devices. The wounds were assessed with plain radiographs and USG at established time intervals. Estimates of bone formation using a semiquantitative bone fill score were made for radiographs and USG. USG bone fill scores were correlated with radiography scores. At week 4 the difference between the scores was statistically significant ($P = 0.01$); at all other time points, USG and radiography scores were comparable. At week 4, USG scores were significantly higher than the corresponding radiography scores, indicating that USG is an earlier indicator of calcification in the distraction zone as compared to radiography. USG evaluation of the distraction osteogenesis (DO) zone has many inherent advantages over conventional methods. The results of this study indicate that USG is an accurate non-invasive technique that may prove to be useful in assessing the mandibular DO regenerate in patients.

Key words: ultrasonography (USG); distraction osteogenesis (DO); semiquantitative.

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Distraction osteogenesis (DO) is a process of new bone formation between the surfaces of bone segments gradually separated by incremental traction, as described by Ilizarov who has pioneered distraction since the 1950s.[1,2]

Presently no fixed protocol exists for the assessment of the distraction regenerate, which could aid in modifying the distraction protocol according to the needs of each patient. Ultrasonography (USG) promises to give an accurate assessment of not only the mandibular regenerate, but also the surrounding soft tissues.

The current commonly used methods for assessment of the clinical DO zone consist of serial physical examinations, plain radiographs, dual energy X-ray absorptiometry (DEXA), and computed tomography (CT). In contrast to these, USG is an inexpensive and efficient method of imaging that provides detailed assessment of bone formation across a defect. It has previously been proved useful for the evaluation of long bone DO healing.[3–7]

The healing DO zone does not contain cortex, hence it can be penetrated by USG waves. This phenomenon is presumed to allow the surgeon or radiologist to

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evaluate the quantity, distribution, and density of the regenerate.[8] Standard radiographic imaging poorly defines the regenerate as compared to the high accuracy of USG. It has been observed that the presence of bone union on radiographs is difficult to evaluate and not reliable during the first 4 weeks of fixation.[9] Various superimpositions in the postero-anterior (PA) view and panoramic radiographs of the skull have a limited application in patients with a distraction device *in situ*. In contrast, USG can easily be adjusted to the area of interest in the mandible. The application is non-invasive, safe, simple, and reproducible.

There is a need to evaluate USG as a diagnostic tool in the evaluation of distraction regenerate, osteogenesis, and soft tissue growth (histiogenesis). The aim of this study was to evaluate the efficacy of USG as an accurate, non-invasive tool for the evaluation of bone formation in patients undergoing mandibular DO. The objective was to evaluate and compare the USG findings vis-à-vis results of assessment with radiographs.

Patients and methods

Twenty-two patients (12 males and 10 females) underwent DO of 30 mandibular sites, which included bilateral ($n = 8$) and unilateral ($n = 14$) procedures. The unilateral DO cases included four bimaxillary DO. Patient age ranged between 10 and 28 years (mean age 19.18 years). Patients from the oral and maxillofacial outpatient treatment department were included, as well as patients referred from allied specialities of the institute on the basis of having existing mandibular hypoplasia (congenital/acquired). The principles of DO were used to correct the existing mandibular skeletal deformities in this group of patients. Patients with neuropsychiatric disorders, on immunosuppressive medication, and those at the extremes of age were excluded from the study.

Evaluation of the regenerate of mandibular DO was carried out; the state of mineralization was evaluated with radiographs and USG at weeks 1, 4, 8, and 24 post distraction by rating on a 4-point semiquantitative scale and comparing the results obtained. A non-parametric test (Wilcoxon signed ranks test) was used to compare the USG and radiograph scores.

Distraction devices

A variety of distraction devices were used, which were placed intraorally ($n = 28$ sites) or extraorally ($n = 2$ sites). The distractors were placed at various mandibular sites, according to the needs of each case. The various sites used were: mandibular body ($n = 8$ sites), ramus ($n = 9$ sites), ramus–condyle unit (RCU) ($n = 4$ sites), mandibular midline ($n = 4$ sites), and simultaneous maxillo-mandibular distraction ($n = 5$ sites) in which the mandible was distracted at the ramus segment. Standard surgical steps with necessary modifications were undertaken.

Distraction protocol

After a latency period of 4 days (based on the site of DO), distraction was performed at the rate of 1 mm/day in 0.5-mm twice a day increments, as per the treatment plan

Table 1. Comparison of USG and radiographic fill at 1, 4, 8, and 24 weeks.

Patient no.	Distraction, mm	USG Week 1	USG Week 4	USG Week 8	USG Week 24	RAD Week 1	RAD Week 4	RAD Week 8	RAD Week 24
1	16.00	0	2	2	2	0	1	2	2
2	23.00	0	2	2	2	0	0	2	2
3	8.50	1	2	2	3	0	0	2	2
4	12.50 (R)	0	2	2	2	0	0	2	2
	16.50 (L)	0	2	2	2	0	0	2	2
5	14.50	0	1	2	3	0	1	2	3
6	20.50 (R)	0	2	2	2	0	1	2	2
	18.00 (L)	0	2	2	3	0	1	2	3
7	8.00	0	1	2	2	0	1	2	2
8	11.50	0	2	2	2	0	0	2	2
9	14.50	0	1	2	3	0	1	2	3
10	9.00 (R)	0	1	2	3	0	1	2	2
	9.00 (L)	0	1	2	3	0	1	1	3
11	18.00	0	1	2	3	0	1	2	3
12	10.00	0	2	2	3	0	0	2	2
13	13.50 (R)	0	2	2	2	0	0	2	2
	13.00 (L)	0	2	2	2	0	0	2	2
14	8.20	0	2	3	3	0	1	3	3
15	6.00	1	2	2	3	0	1	2	2
16	12.50 (R)	0	1	2	3	0	1	2	3
	15.50 (L)	0	1	2	2	0	1	2	2
17	12.00	0	2	3	3	0	1	3	3
18	14.00 (R)	1	2	2	3	0	1	1	3
	14.00 (L)	0	1	2	2	0	1	2	2
19	18.00	0	1	2	2	0	0	2	2
20	10.50 (R)	0	1	2	3	0	1	2	3
	9.00 (L)	0	1	2	2	0	1	2	2
21	21.50	0	2	3	3	0	1	2	3
22	11.00 (R)	0	1	2	2	0	1	2	2
	9.50 (L)	1	1	2	2	0	1	2	2

USG, ultrasonography; RAD, radiography; R, right; L, left.