The Response of Alveolar Bone to Grinding with Rotary Diamond Stones

REPORT ONE

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In recent years reshaping the alveolar bone with diamond stones has been described as an important adjunct in the treatment of periodontal pockets. This procedure has been justified on the grounds that it is often necessary in order to create physiologic bone architecture and prepare an osseous foundation for the gingiva to rest upon. It has also been stated that unless the alveolar bone is properly contoured by artificial means, the treatment of periodontal pockets, under certain circumstances, is destined to failure. In contrast with the number of claims made for the benefits of bone contouring, the literature contains no evidence regarding the microscopic changes induced by grinding alveolar bone with rotary diamond stones. A study was, therefore, undertaken in experimental animals to investigate this problem.

MATERIALS AND METHODS

The periodontal tissues of the maxillary and mandibular premolars and the mandibular first molars of four mongrel dogs were used in this study. These animals lived in the animal farm for approximately one year prior to their use for experimental surgery and were estimated to be three to four years old. During that time they were fed Purina Dog Chow ad libitum. Their weights ranged from 6.0 kg. to 8.7 kg. at the beginning of the experiment. All animals had generalized chronic marginal gingivitis with an accumulation of supragingival calculus but none of the dogs showed clinical or roentgenographic evidence of destruction of alveolar bone.

All procedures were performed with the dogs anesthetized by an intraperitoneal injection of sodium nembutal; 36 mg. per kg. of body weight. Onset of anesthesia required about ten minutes. The jaws were photographed and radiographed at the onset of the experiment.

Operated Control Areas. The operated control areas were treated as follows: A wax impression was taken of the buccal aspect of each area and casts were made which were used for the construction of acrylic stents.

A horizontal narrow shallow groove was cut through the enamel and into the dentine on the buccal surface of each tooth so as to establish a fixed reference point from which measurements to the crest of the buccal alveolar bone could be made.

An unembellished gingivectomy was performed on the buccal surface of each operated area to remove the marginal gingiva. This was followed by two vertical incisions from the cut edge at the gingival margin to the mucobuccal fold; one mesial to the first premolar and the other distal to the first molar. A mucoperiosteal flap was care-
fully elevated exposing the buccal bone. The distance from the reference notch to the crest of the buccal alveolar bone was measured with an adjustable bow divider and read to the nearest tenth of a millimeter using a Boley gauge. The reflected flap was then sutured back into position.

Operated Experimental Areas. Operated experimental areas were treated the same as the controls with the following additional procedures before the flap was returned to position:

I. Contouring the Buccal Bone in Relation to the Tooth Surface.

The buccal bone was contoured using a mounted coarse diamond stone rotating at slow speed and cooled by bathing with water. Contouring consisted of reducing the thickness of the buccal bone along the mesio-distal length of the tooth and the production of accentuated vertical sluiceways in the bifurcation areas (Figs. 1 and 1A). Grinding was confined to the gingival half of the buccal bone. The bone at the margin was thinned but not reduced in height. The area was cleansed of all debris before the flap was sutured back into place.

II. Contouring the Buccal Bone in the Interdental Areas.

With the diamond stone the buccal bone was ground in the interdental areas so as to produce accentuated sluiceways. Grinding was confined to the gingival half of the buccal bone. The bone was not reduced in height. The area was cleansed of all debris before the flap was sutured back into place.

Kirkland-Kaiser periodontal pack was used as a dressing for the operated control and experimental areas. The pack was held in position by previously constructed stent which were wired to the teeth three weeks after operation. The stents, periodontal pack and sutures were removed. The animals were fed a diet of ground canned meat throughout the experiment.

Unoperated Areas. Other areas were used to provide the microscopic sections of unoperated periodontium.
The animals were sacrificed by intraperitoneal injection of an overdose of sodium pentobarbitol; 72 mg. per kg. of body weight. Two dogs were sacrificed 14 days postoperatively and two 28 days postoperatively. This provided two operated control and experimental areas at intervals of seven, 14, 21 and 28 days after operation (Table I).

At the time of sacrifice each operated area was dissected from the jaws and fixed in 10% neutral formalin for a minimum of two weeks. After fixation and before decalcification a strip of gingiva about two millimeters wide and extending from the free gingival margin to the alveolar crest was removed so as to expose the alveolar bone in the area of the operative measurements. Comparable postoperative measurements were made from the reference notch to the exposed alveolar crest.

Complete decalcification using a mixture of equal parts of 20% sodium citrate and 45% formic acid required approximately seven weeks, with daily changes of solution. The decalcified quadrants were washed in running tap water for 48 hours and trimmed to suitable size for embedding in paraffin. The blocks were cut in serial bucco-lingual sections 6 microns thick, and stained with hematoxylin and eosin and Mallory's connective tissue stain.

**EXPERIMENTAL FINDINGS**

This report deals with findings in the buccal bone in relation to the tooth surface. The findings in the interdental areas will be the subject of a future report.

**Gross Observations.** There were no appreciable differences in the gross appearance of the operated control and experimental areas at each postoperative interval.

When the stent and periodontal pack were removed seven days after operation, there was a band of bright red granulation tissue at the gingival margin of the wound which extended interproximally and joined the lingual portion of the interproximal papillae. The buccal flap was covered with materia alba which was easily wiped off.

By 14 and 21 days after operation, the flap was slightly bulbous with a smooth glistening appearance and was reduced in redness. A thin band of granulation tissue formed the gingival margin.

At 28 days after operation, the operated area appeared normal in color and contour except for a marginal edema and enlargement.

**Roentgenograms.** Roentgenograms were made of the control and experimental areas preoperatively and at seven, 14, 21 and 28 day postoperative intervals using the long cone technique. The films (Kodak Periapical Radiatized, Code DF-7) were exposed at 65 kvp. and 10 ma. for two seconds and processed according to the manufacturer's instructions.

No significant differences could be detected between preoperative and postoperative...
tive roentgenograms of the operated control and experimental areas.

Measurements. The changes in the postoperative measurements made from the reference grooves on the crown of each tooth to the crest of the alveolar bone are expressed as averages in Table II. Since the Boyle gauge used in reading these measurements is accurate to one tenth of a millimeter, the average changes in the height of the buccal bone after operation are only accurate to plus or minus one tenth of a millimeter.

The findings indicate that grinding did not affect a notable change in the bone level at seven and 14 days after operation. However, at 21 and 28 days postoperatively the height of the buccal bone was notably reduced in the operated experimental areas. In extreme cases average reductions of 1.7 mm. and 1.2 mm. were noted. In the operated control areas, loss of buccal bone height was slight and ranged from 0 to 0.5 mm.

Microscopic Findings. In general no findings in the maxilla were more severe than in the mandible. In the experimental areas of the maxilla with necrosis occurred, it was extremely difficult to consistently obtain nonfragmented sections satisfactory for comparison with control areas. For this reason the mandible was used to evaluate the microscopic findings.

Unoperated Areas. The margins of the operated gingiva were well formed with a stratified epithelium and densely collagenous connective tissue (Fig. 2). The fibers could be traced from the cementum of the adjacent marginal alveolar process into the gingiva. There was a slight infiltration of leukocytes in the marginal gingival base of the sulcus.

The periodontal membrane was intact and there was evidence of osteoid bone formation along the adjacent cementum surfaces (Fig. 3).

Table II

<table>
<thead>
<tr>
<th>Postoperative Interval</th>
<th>Tooth</th>
<th>Changes* in Buccal Bone Height (Operated Control Areas)</th>
<th>Changes* in Buccal Bone Height (Operated Experimental Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maxilla</td>
<td>Mandible</td>
</tr>
<tr>
<td>7 Days</td>
<td>1</td>
<td>+0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>+0.1</td>
<td>+0.4</td>
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<tr>
<td></td>
<td>3</td>
<td>-0.2</td>
<td>-0.1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>+0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>14 Days</td>
<td>1</td>
<td>+0.3</td>
<td>+0.1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>+0.1</td>
<td>-0.5</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>+0.2</td>
<td>+0.4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-0.3</td>
<td>-0.2</td>
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<tr>
<td>21 Days</td>
<td>1</td>
<td>-0.2</td>
<td>-0.1</td>
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<tr>
<td></td>
<td>2</td>
<td>-0.5</td>
<td>-0.7</td>
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<tr>
<td></td>
<td>3</td>
<td>-0.1</td>
<td>-0.1</td>
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<td></td>
<td>4</td>
<td>+0.2</td>
<td>0.0</td>
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<tr>
<td>28 Days</td>
<td>1</td>
<td>-0.3</td>
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<tr>
<td></td>
<td>2</td>
<td>-0.5</td>
<td>+0.1</td>
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<tr>
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<td>3</td>
<td>-0.3</td>
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<tr>
<td></td>
<td>4</td>
<td>-0.2</td>
<td>0.0</td>
</tr>
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*Changes are expressed in millimeters, ±0.1 mm.
(+) = gain in height of buccal bone.
(−) = loss in height of buccal bone.
The buccal aspect of the alveolar bone was covered by dense periosteum with an inner osteogenic zone. There was new bone formation along the buccal and periodontal membrane surfaces in the crestal region. Reversal lines were present in the bone indicative of previous resorptive activity. In the more apical area of the buccal bone there were occasional isolated osteoclasts on the surface.

Seven Days Postoperative. Operated control areas, muco-periosteal flap detached from the buccal surface of the alveolar bone and replaced.

The marginal gingiva was restored and at its base appeared to be attached to the tooth slightly beneath the cemento-enamel junction (Fig. 4). On its outer aspect the marginal gingiva was covered with well formed epithelium which was continuous with that of the attached gingiva. On the inner aspect of the sulcus, the epithelium was thin and devoid of rete pegs. At the crest of the gingival margin the epithelium was hyperplastic and extended into the underlying connective tissue.

The connective tissue of the marginal gingiva presented a moderate leukocyte infiltration. There was an associated hydropic degeneration of the epithelium. A few fragments of necrotic calcified material were observed in the connective tissue of the attached gingiva.

Between the buccal surface of the alveolar bone and the replaced flap there was a broad zone of fibrin clot undergoing organization (Fig. 5). In this area deposits of hyaline connective, new blood vessels, fibroplasia and a slight suggestion of fibrous material were observed interspersed with a
dense leukocytic infiltration. There was considerable variation in the severity and distribution of the inflammation in different sections of the same specimen.

There were no noteworthy changes in the buccal surfaces of the alveolar plate. In the region of the crest of the bone lacunae containing osteoclasts were observed.

Along the entire length of the periodontal membrane, there was slight edema and leukocytic infiltration with disorganization of the fiber bundle arrangement. At the level of the crest of the bone, there was a notable zone of cementoid with an adjacent layer of cementoblasts and partially embedded coarse fibers. Individual fibers extended from the cementum toward the crest of the alveolar bone.

Operated experimental areas, mucoperiosteal flap detached from the buccal surface of the alveolar bone, alveolar bone contoured by grinding previous to the replacement of the flap.

The operated experimental areas differed from the operated controls in the following respects: The clot which extended along the buccal surface of the alveolar plate beneath the flap was almost entirely replaced by a dense leukocytic infiltration (Figs. 6 and 7). The crestal portion of the labial plate was necrotic. The marrow spaces of the bone in the crestal portion of the buccal plate were devoid of cells. The adjacent lacunar spaces were devoid of osteoblasts.

Further apically in the alveolar plate, the marrow was replaced by inflammatory cells. There were numerous osteoclasts among the endosteal surfaces of the marrow spaces. In isolated sections, large segments of the crestal portion of the alveolar plate were separated from the underlying bone by an intervening zone of leukocytes.

The periodontal membrane of the operated experimental areas was more intensely involved by inflammatory cells. There was active resorption of the alveolar bone adjacent to the periodontal membrane with enlargement of the marrow spaces. The bone
in the crest was resorbed and presented isolated fragments which were almost completely encompassed by osteoclasts.

_Fourteen Days Postoperative._ Operated control areas—Healing in the fourteen day specimen was advanced over that observed in seven days.

In the gingival margin, the epithelium showed evidence of hyperplasia and was attached to the tooth at the cemento-enamel junction or slightly apical to it (Fig. 8). The gingival fibers were well formed and embedded in new cementum on the root immediately subjacent to the epithelial attachment.

The connective tissue fibers in the periodontal membrane were well formed. At the alveolar crest, there was an attempt at the transformation of definitive fiber groups, but the irregular arrangement seen in unoperated animals was not attained.

The area of the clot on the buccal aspect of the bone was replaced by loose fibrillar connective tissue which could be differentiated from the old well formed collagen bundles of the flap (Fig. 9).

The height of the buccal bone was slightly reduced compared to that observed in the unoperated animals. The buccal surface of the bone was lined with osteoblasts which formed the inner layer of a multilayered periodontal. Near the buccal surface there were occasional reversal lines in the bone where resorption had previously occurred and where new bone had filled in the destroyed areas.

New bone formation was observed at the crest of the buccal plate. There was some evidence of endosteal osteogenesis in the marrow spaces adjacent to the periodontal membrane and those close to the lateral bony surface. In the apical region of the buccal aspect of the alveolar plate the width was increased by prominent trabeculae of new bone.

Occasional small areas of cellular resorption were observed in the tooth surface.
Fig. 9. Operated control area 14 days post-operative, showing intact marginal epithelium and underlying bone. Note the inflammatory infiltrate and epithelial hyperplasia in the marginal epithelium. Hematoxylin and eosin. X 50.

These extended for varying depths into the dentine and were partially filled with newly formed cementum.

Operated Experimental Areas—The operated experimental areas differed from the operated controls as follows:

Maturation of the clot between the buccal bone and flap had not progressed to the extent observed in the controls. In some specimens supplicative inflammation was observed in the clot area bordering the bone (Figs. 10, 11). In other specimens there were pools of fibrillar material without definite fiber arrangement. Others showed some suggestion of a zone of thin parallel fibers with interspersed leukocytes. There was a suggestion of a peritoneum formed by a dense band of fibers and flattened connective tissue cells along the buccal bone surface, but no evidence of osteogenic activity.

The height of the buccal alveolar bone was slightly reduced. In some instances it was estimated, by use of a caliper, that as much as 10% of the bone had been destroyed compared to unoce animals. Resorption was observed crest.

The buccal bone surface was irregular with occasional osteoclasts 1 in lacunae. Marrow spaces adjacent surface and for a considerable depth crestal portion were filled with leuk and fibroblasts. A thin layer of osteoporesent along endosteal surfaces.

Twenty-One Days Postoperative areas—The marginal gingivofacial bone consisted of dense relatively uniform collagen bundles (Fig. 12). The periodontal membrane presented the normal bundle arrangement.

The height of the buccal alveolar bone was slightly reduced in comparison wit
This was particularly marked in the coronal portion where there was no evidence of old bone trabeculae. The entire area consisted of linear trabeculae of new bone with a bordering zone of osteoblasts, thin osteoid, and an occasional osteoclast (Fig. 16). Part of the apical portion of the buccal plate consisted of old bone but the outer aspect was formed by new bone trabeculae.

The periodontal membrane was densely collagenous. In the apical half there was a suggestion of regular bundle arrangement between the old bone and the tooth. In the coronal portion the collagen fibers were aligned vertically, parallel to the tooth and trabeculae of new bone.

Twenty-Eight Days Postoperative. Operated control areas—The gingival margin was well formed and presented varying degrees of inflammation.

The reduced height of the buccal alveolar bone was estimated, by use of a calibrated...
eyepiece, at 15% when compared to the unoperated areas (Fig. 17). In some specimens the contour of buccal alveolar bone was affected so that it was thinned midway along the root and appeared relatively bulge-out at the margin (Fig. 18).

**Operated experimental areas** — Noteworthy differences between the operated experimental and operated control areas were observed in the buccal alveolar bone. The reduction in bone height, as estimated by use of a calibrated eyepiece, was as much as 40% compared to unoperated areas. In some instances, only half of the labial plate was present (Fig. 19). New trabeculae at the crest suggested an attempt at restoration of the destroyed bone (Fig. 20). The width of the gingiva attached to the root was almost twice that observed in the controls. The buccal bone presented the same altered contour as observed in the operated control areas (Fig. 21).

**Discussion**

The experimental procedure was performed after clinical practice, but it was single purpose of the experiment to determine the effect of grinding alveolar bone with a rotating diamond stone. The discussion will be confined to this subject as it will deal with the buccal bone in relation to the tooth surface. The bone in the periodontal area will be considered in a subsequent report.

The findings indicate that grinding with a diamond stone is injurious to alveolar bone. It causes bone necrosis, impairs post-operative healing and leads to a reduction in bone height. This occurs despite the fact that the diamond stone is rotated slowly; the area is cooled with water and the grinding is limited to thinning the buccal bone without reducing the height.

The most significant difference between the healing of the operated control and ex
Fig. 15. Operated experimental area 21 days postoperative showing thinned buccal alveolar bone. In the upper portion the alveolar bone is formed entirely of new trabeculae; in the lower portion new trabeculae are formed upon the remnants of old bone. Desmoplasia and bone. Original X 20.

Operated experimental area 21 days postoperative showing inflammation in marginal and other reparative area of resorption and a repairable area of resorption and a repairable surface. Note the alveolar bone has been so that no bone is visible in this section with Figure 15. Histologically an ossa.

In the operated experimental areas the inflammation persisted beyond the seventh day and interfered with organization and maturation of the clot. A well formed periosteum and osteogenic activity could be demonstrated on the surface of the buccal bone.

In the operated experimental areas the inflammation persisted beyond the seventh day and interfered with organization and maturation of the clot. By the seventh day there was evidence of bone necrosis at the surface of the buccal plate as well as necrosis of a large segment at the margin where the bone had been ground. Persistence of the inflammation may be attributable to some measure to irritation from the necrotic buccal plate.

By the seventh day granulation tissue from the periodontal membrane and from
the buccal connective tissue extended into the marrow spaces. There was an associated resorption of the surrounding bone and enlargement of the marrow spaces. In some instances sequestra of necrotic crestal bone were detached from the underlying bone by the union of granulation tissue from the periodontal membrane and buccal connective tissue.

Small isolated fragments of necrotic bone were observed in the connective tissue near the buccal crest in the operated experimental area but they were also present in the operated controls. An inflammatory reaction was localized around such fragments in both experimental and control areas.

The gross measurements and the measurements made on the microscopic slides indicated a marked reduction in the postoperative height of the buccal bone ground with diamond stones when compared with unground specimens. Computations made on the microscopic sections of 28 day specimens indicated as much as a 40% reduction in bone height in some of the sites. Only a 1/2 reduction in height served in the area which were.

More measurements would be additional animals before the bone loss which resulted from could be expressed in determinative.

The findings do indicate that growth leads to far more extensive destruction than less severe extractions. The curettage and flap operation is not necessary.

Mention should be made of the no bone loss could be detected graphically in either the operated or experimental areas even after a perimolar period. The reduction in the height of the root area of the controlled control areas and the microscopic findings were present in the root. The original specimens had been lost.
is interesting that the restoration of marginal periodontium was comparable to the operated control and experimental groups despite the marked differences in the gingival sulcus of the underlying bone. At no time in the experiment did the location of gingival margin on the tooth surface reflect the lowered levels of the crest of the gingival bone. By seven days in both the experimental and control areas, the gingival margin had been restored to its original position by gingivectomy. Throughout the remainder of the experiment, the base of the gingival sulcus was located at or near the cemento-enamel junction despite the reduced height of the plate in the experimental areas, in the experimental areas the gingiva attached to the newly formed cementum was almost twice that of the control.

In the operated control and experimental areas, new cementum and new fibers were formed beneath the base of the gingival sulcus by the seventh day. They extended into the newly restored gingival margin and toward the alveolar bone.

By 21 days there was evidence that part of the destroyed bone in the operated experimental areas had been restored. In fact, the coronal portion of the buccal plate consisted entirely of new bone. There was a remnant of old bone adjacent to the periodontal membrane in the apical region of the labial plate. However, despite the presence of bone regeneration at the 21 day
Contour can be predetermined by artificial reshaping during treatment. The buccal bone that was reshaped by grinding underwent necrosis and was resorbed. The ultimate contour of the buccal bone is determined by trabeculae of new bone formed in the course of healing, long after the grinding procedure.

The height of the partially restored buccal bone in the area ground with diamond stones was notably less than that in areas in which the bone was not ground. However, the bone contour in both areas was similar. It would appear that factors other than grinding with diamond stones affected the bone contour produced by healing which followed the experimental procedures.

Extending the experimental period beyond 28 days used in the present study could provide more information regarding the regeneration of the destroyed buccal bone with areas ground with diamond stones. As pointed out earlier, reports of tissue changes following the grinding of alveolar bone with diamond stones have not as yet appeared in the literature. However, reduction in buccal bone height has been reported following mucogingival surgery which included the elevation of mucoperiosteal flaps, denudation, scraping and exposure of the buccal bone.\textsuperscript{11,12} Postoperative periods up to 181 days were used, but only one-half of the bone destroyed by the experimental procedure was restored and this occurred by 91 days.

**SUMMARY AND CONCLUSIONS**

A study was conducted in experimental animals to investigate the response of alveolar bone to artificial contouring by rotating diamond stones. The experimental procedure was patterned after clinical practice.

Mongrel dogs with chronic marginal gingival disease were used as experimental animals. A gingivectomy was performed on the buccal surface and was followed by elevation of a mucoperiosteal flap which was detached from the buccal alveolar bone. In the operated control areas the flap was

*Fig. 20. Operated experimental area 28 days postoperative. Cross of the hepar plate is formed in the buccal side of new bone. Note the fluid of bone following removal of the buccal area. Haematoxylin and eosin, H. E., mag. X 36.*

*Fig. 21. Diagrammatic representation of altered contours of the buccal bone in the operated experimental (C) and operated control (B) areas as compared with the buccal bone in the unoperated (A) area.*

interval, maximum reduction in bone height was observed in the 28 day specimens.

The findings cast some doubt upon the clinical impression that postoperative bone
replaced and sutured into position. In the
operated experimental area the buccal bone
was contoured in relation to the tooth sur-
face by slowly rotating diamond stones
grains with cold water before replacing
and suturing the flap. The contouring con-
trasted the gingival half of the buccal bone
along the middle-distal length of the tooth
and accentuating the buccal groove in the
bifurcation area. Unoperated segments were
used for reference for subsequent
microscopic comparisons.

The findings indicate that grinding with
a diamond stone is injurious to the alveolar
bone because it causes necrosis, impairs heal-
ing and leads to a reduction in bone height.
Doubt is cast upon the impression that bone
contour can be predetermined by reshaping
during periodontal treatment. The ultimate
buccal contour is not formed by the re-
shaped bone. It is determined by new bone
formed in an unsuccessful attempt to re-
place bone destroyed by grinding.

The assistance of Miss Florence Davis, research
technician in our laboratory, who prepared the
specimens for microscopic study is gratefully
acknowledged.

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ALPHA OMEGA FRATERNITY

An Illinois Chapter of The Alpha Omega Fraternity is sponsoring a Seminar on Periodontics given by
Paul Schlager, Director of Graduate Study, University of Washington, Seattle. All members of the
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Luncheon will be held at 12:00 noon.

Checks to: Julian Caplan, 4402 Broadway, Program Chairman.