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The effect of oral irrigation with a magnetic water treatment device on plaque and calculus

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Abstract. Calculus formation on tooth surfaces is analogous to the formation of lime and scale deposits in plumbing. Magnetic water devices have been shown to significantly reduce scale deposits in industry; therefore an oral irrigator with a magnetic water device may have a similar effect on calculus. To test this hypothesis, a double-blind clinical study was established using 64 irrigators, 30 of which had their magnetic devices removed. 54 patients with heavy supragingival calculus were given irrigators at random after prophylaxis. Instructions were given to irrigate twice a day, particularly the lower 6 anterior teeth. The patients were also told not to floss these 6 teeth which were to be the study teeth. They were examined after 3 months and measurements were taken of the accretions adhering to the study teeth. No attempt was made to determine whether the adhering material was hard or soft so it must be assumed that at least some of the measured material was also plaque. The measurements of the group using an irrigator with a magnetic device showed a 44% greater reduction in calculus volume ($p < 0.0005$) and a 42% greater reduction in area ($p < 0.0001$) over the group using an unmagnetized irrigator. There appears to be a statistically significant difference in supragingival accretion volumes between conventional irrigation and using an irrigator with a magnetic water treatment device.

Key words: irrigation; magnetic water treatment device; adherence; supragingival calculus reduction; stern layer; divalent cations.

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Adherence of supra-gingival calculus and its accompanying bacterial plaque to the surfaces of teeth has been implicated as a possible factor in initiating periodontal diseases. Tooth brushing has been universally accepted as the standard method of oral hygiene to control the formation of supra-gingival calculus. Standard oral hygiene procedures have greatly improved dental health, but periodontal diseases are still common and pose a tremendous health care expense (Sheiham 1991).

Many studies have demonstrated that the use of irrigation devices may be an effective means to reach into areas inaccessible to toothbrushing. The addition of agents such as chlorhexidine and fluoride have increased this effectiveness (Flint et al. 1988, Vignarajah et al. 1989, Wikesjo et al. 1989, Landet et al. 1986). Another method of increasing the effectiveness of irrigation may be through the use of magnets.

The application of magnetic water treatment devices has been used in Eastern Block countries and China for over twenty-five years (Hibben 1973). Grutsch & McClintock (1984) demonstrated a positive corrosion and deposit control by the use of magnetically-treated water at an AMOCO refinery. Kronenberg (1985) described the observations of reduced formation of new hard lime scale deposits and the elimination of old lime scale deposits. A Baylor research team (McAtee et al. 1985) under contract from the American Petroleum Institute concluded that "the passage of conducting solutions (tap Water) through a magnetic treatment device generates voltages and currents which result in an electrolysis reaction, producing nucleation centers that favor precipitation of scaling salts in the bulk of the solution rather than on the walls of plumbing".

Certain theories have been proposed to explain mechanisms of adherence of calculus. It has been shown that amphipatic substances change the charge of the tooth surfaces, which can effect the attachment of bacteria (Krasse 1977). Ca^{++} and PO_4^{--} ions are concentrated on hydrated tooth surfaces (Stern Layer) which are covered by a protein pellicle. Rolla (1977) stated "that gram positive bacteria are negatively charged and these bacteria are the first colonizers of the negatively charged tooth surface. The well-known delay (3–4 h) which may be observed before bacteria colonize teeth may well be ascribed by the repulsive forces between the surfaces involved. Divalent cations will reduce the repulsion and permit the bacteria to

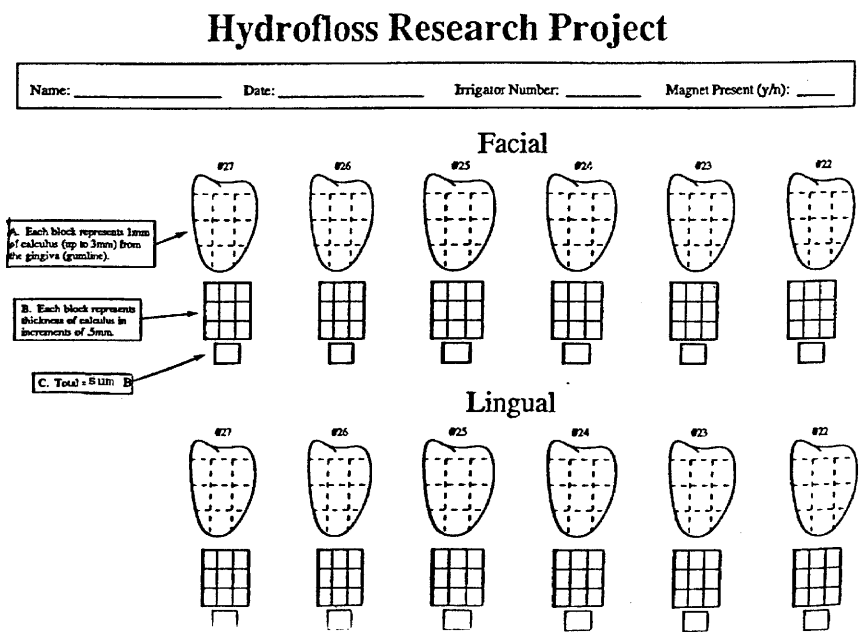

Fig. 1. A value of 1, 2, or 3 was recorded in the boxes for thickness.

approach the teeth. An adhesion based on some specific interaction may be the final stage of the electrostatically mediated approach of the bacteria to the tooth surface." It can be hypothesized that this adhesive interaction is similar to the naturally occurring phenomena of adherence of particulate matter to any hard surface in an aquatic environment and that this adherence may be adversely affected by magnetic devices.

Recently, an oral irrigator with a magnetic device was manufactured. Unpublished preliminary clinical pilot studies have indicated positive results (Watt 1987, Volmer & Barger 1988) along with numerous anecdotal reports by several dental clinicians. Therefore a double-blind clinical trial was established to test this hypothesis.

Material and Methods

64 irrigation units were provided by the manufacturer, 30 of which had their magnetic devices removed. The units were coded and the examiner did not know which units had magnetic devices and which did not.

54 patients were selected because they formed heavy calculus and they had been successfully treated for periodontal disease. They were currently being seen on a 2–4 month recall for maintenance.

All patients received a thorough scaling and prophylaxis and had the tooth surfaces carefully examined by 2 clinicians. They were instructed in the use of the assigned irrigator, concentrating on a thorough lavage of the lower 6 anterior teeth 2× a day. These 6 teeth were not to be flossed, but the patients were to continue normal maintenance procedures otherwise. They were appointed for a recall visit in 3 months.

At the recall visit, the patients were questioned about their compliance. If the patients stated that they were unable to perform the irrigation properly for more than 14 days, they were removed from the study. Three patients were removed for this reason. Two patients reported that they had flossed the study teeth. 7 patients reported irrigator malfunction and two patients were traveling and could not schedule an appointment within 3 weeks after their 3-month period. A total of 14 patients were removed from the study. For the remaining patients, the study teeth were stained with green food coloring and the same examiner performed all evaluations. The teeth were first air dried and the adhering residues were measured by comparing their height from the gingival margin and thickness to a "Michigan O" periodontal probe. Measurements were taken in 6 places on each tooth (DF, F, MF, ML, L, and DL). The majority of the adhering residue was most likely calculus but, because no attempts were made to remove plaque and the residues were not probed to determine if they were hard or soft, it seems most appropriate to state that the residues were both plaque and calculus.

The value for the height measurement was confined to 3 mm from the gingival sulcus. Thus by dividing the tooth surface at each of the 6 measurement sites into 3 regions of 1 mm height each, altogether there were 18 areas on each tooth at which thickness could be measured (see Fig. 1). For each area, the thickness measurement was recorded using the following code: 0.5 mm = 1, 1 mm = 2, 1+ mm = 3. The sum of the 18 thickness codes represents an empirical measurement which is correlated to the total volume of calculus and plaque on a tooth, and by adding together the 6 individual tooth volume measurements an overall volume score was obtained for each patient.

An empirical score representing the total tooth area covered by calculus and plaque was also recorded. This score was obtained by counting the number of 1 mm high tooth regions (out of a possible total of 108) that had at least 0.5 mm thick covering of calculus and plaque.

Results

The observed distributions of the volume measurements displayed in Fig. 2 suggests that the presence of the mag-

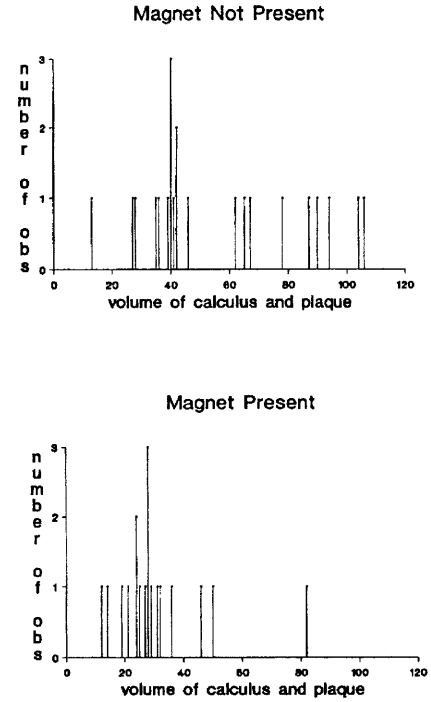

Fig. 2. Distributions of the measured volumes.

netic device in irrigators causes a distributional shift in the amount of calculus and plaque formed. There seems to be an overall tendency for lower volume scores among the magnetic water group. Smaller values for the sample mean (30.89 versus 55.55, a reduction of 44%) and the sample median (28 versus 42, a reduction of 33.3%) serve to summarize the difference in average values for the two distributions.

Fig. 2 also indicates a decreased variability in the volume scores for the patients who had used the irrigators furnished with magnets. This observation is supported by the fact that the magnetic water group has both a smaller sample standard deviation (16.9 versus 26.9) and a smaller interquartile range (9.75 versus 42) than the unmagnetized water group.

The combined effect of reductions in both the location of central tendency and the amount of distribution spread which are apparently due to the treatment effect of the magnetized water is a propensity to obtain a decreased proportion of patients having large amounts of calculus and plaque when compared to the amount which result when unmagnetized water is utilized. It is noteworthy that 9 of the 22 patients who used un-magnetized irrigators had volume scores of 62 or greater, while only one patient from the magnetized water group had a score that high. Formally, it seems best to describe the distributional shift by stating that the distributions for the magnetized water group appear to be stochastically smaller than the distributions of the unmagnetized group (which implies a smaller distribution mean). The Mann-Whitney *U*-test can be used to show that the observed distributional shift is statistically significant, and in this case the data yields the highly significant result $p < 0.0005$.

The effect of the magnets in the irrigators can also be assessed by comparing the area scores for the calculus and plaque measured for the two groups. A thorough analysis of the data yields results analogous to those obtained from the volume measurements. Overall, the distribution of area scores for the magnetized water group is stochastically smaller than the distribution of scores for the unmagnetized water group ($p < 0.0001$ by the Mann-Whitney *U*-test). The magnitude of the distribution shift can be summarized by a comparison of the sample means and the sample standard deviations. The mean of the eighteen area scores for the magnetized water group (26.50) is 42% smaller than the mean for the 22 area scores for the unmagnetized water group (62.32), and a reduction in the standard deviation is also observed (10.04 versus 18.35).

Discussion

On the basis of the preceding statistical analysis one can conclude that a magnetic device properly attached to an oral irrigator appears to greatly reduce the formation of supra-gingival calculus and its accompanying plaque. This author is unaware of any other similar studies in the dental literature and, if other independent studies result in findings similar to those reported here, it is logical to assume that such an irrigator would then be of extreme benefit to a self-care oral hygiene regime.

One can speculate that the probable mode of action of magnetically treated water affects the Ca^{++} and PO_4^{--} ions in the stern layer by bringing these ions closer together, thus reducing their activity. This could, in turn, reduce the effect of free divalent cations in mediating attachment. Another possibility is that the amount of free divalent cations is reduced because the magnetized water encourages their precipitation.

An excellent research question would be if the addition of chemical agents, such as salt solutions, to the irrigation solution could enhance or hinder the effect on calculus. Further, long-term studies need to be completed to assure that there are no side effects such as reduced hydration of the tooth surfaces which may be detrimental to tooth vitality. However, such side effects are highly unlikely.

Zusammenfassung

Die Wirkung von Mundspülungen auf Plaque und Zahnstein bei Anwendung eines Geräts für Behandlung mit magnetischem Wasser

Die Bildung von Zahnstein auf Zahnoberflächen ist mit der Ablagerung von Kalk- und Kesselstein in Röhren vergleichbar. Es hat sich gezeigt, daß Geräte für die Spülung mit magnetischem Wasser imstande sind, die in der Industrie vorkommenden Kesselsteinablagerungen wesentlich zu reduzieren. Ein Mundspülgerät mit einem Zusatz für magnetisches Wasser könnte eine ähnliche Wirkung auf den Zahnstein entfalten. Um diese Hypothese zu testen, wurde eine doppelblinde, klinische Studie mit 64 Mundspülgeräten konzipiert – für die bei 30 Geräten der magnetische Zusatz entfernt wurde. Nach einer Prophylaxebehandlung wurden diese Mundspülgeräte an 45 Probanden mit ähnlicher Menge supragingivaler Zahnsteinanlagerungen, in zufälliger Reihenfolge verteilt. Die Probanden wurden instruiert, den Mund 2 mal täglich zu spülen – besonders sorgfältig die 6 unteren Frontzähne. Weiterhin wurde mitgeteilt, daß diese, für die Studie wichtigsten 6 Zähne (Testzähne), nicht mit dem Seidenfaden (dental floss) gereinigt werden dürften. 3 Monate später wurden die Probanden erneut untersucht und die an den Testzähnen adhärierenden Anlagerungen gemessen. Zwichen harten oder weichen Anlagerungen wurde nicht unterschieden, man kann also annehmen, daß zumindest ein Teil des begutachteten Materials aus Plaque bestand. Im Vergleich zu der Gruppe ohne den magnetischen Zusatz, zeigten die Messungen an der Gruppe mit dem magnetischen Zusatz zum Mundspülgerät, eine 44% höhere Reduktion des Zahnsteinvolumens ($p < 0.0005$), und eine 42% größere Reduktion des gleichen Parameters an den Zahnoberflächen des Testgebiets ($p < 0.0001$). Es scheint also ein statistisch sichergestellter Unterschied des supragingival haftenden Belagvolumens zwischen den mit konventionaler Spülung behandelten und den Probanden, bei denen ein magnetisches Zusatzgerät bei der Wasser-Spülbehandlung vorhanden war, vorzuliegen.

Résumé

Effet d'une irrigation buccale avec un système magnétique de traitement de l'eau sur la plaque dentaire et le tartre

La formation de tartre sur les surfaces dentaires est semblable à celle rencontrée en plomberie. Des systèmes de traitement magnétique de l'eau ont été utilisés en plomberie et pourraient donc être essayés en médecine dentaire. Une étude à double insu a été menée avec 64 appareils d'irrigation buccale dont 30 ont été privés du système magnétique. Après prophylaxie, 54 patients avec beaucoup de tartre sus-gingival ont reçu un appareil. Ils devaient irriguer leurs dents deux fois par jour en insistant sur la région linguale des incisives et canines inférieures. De plus, ils ne devaient pas utiliser la soie dentaire dans cette région. Après trois mois, la quantité de l'ensemble tartre-plaque a été mesurée. Le groupe utilisant le système magnétique, accusait une réduction de volume de 44% ($p < 0.0005$) et de surface de 42% ($p < 0.0001$) vis-à-vis du groupe utilisant un appareil sans ce système.

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