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Original Article

A Comparative Study of Oral Hygiene Habits and Drinking Water In Sharqiyah Province Versus Riyadh in Relation to Dental Calculus Accumulation

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ABSTRACT

Aim: The aim of this study was to compare dental calculus severity, type of drinking water, and oral hygiene habits between two provinces in the Kingdom of Saudi Arabia which are Sharqiyah and Riyadh in order to investigate if the type and content of drinking water in Saudi Arabia have any effects on dental calculus formation and accumulation.

Materials and Methods: 202 patients age from 16-40 years old divided equally Riyadh/Sharqiyah were examined clinically using calculus index and pH saliva test (using pH indicator papers full range). Each patient answered questions about: oral hygiene habits including the last visit for scaling, dietary system, smoking, type of drinking water and the amount of daily water consumption. Drinking water samples lab analysis was done for different types: Desalination tap water, trucks loaded water, and bottled water. A statistical analysis was done.

Results: There is difference between the two provinces P-value<0.05 in calculus risk, type of water and saliva pH. There is no difference between the two provinces in smoking habits, oral hygiene habits, and the amount of daily drinking water P-value>0.05.There is a statistically significant relationship between type of water and calculus also between provinces and calculus. Sharqiyah depends more on trucks loaded water and desalination tap water and has a higher calculus risk than Riyadh that mainly depends on bottled water.

Conclusion: The content of drinking water in Saudi Arabia helps to form dental calculus depending on the source of drinking water concerning the levels of (Ca^{2+}), (PO_4^{3-}), (Mg^{2+}).

KEYWORDS: Calculus, Type of Water, Bottled, Desalination, Tap Water.

INTRODUCTION

Drinking Water and the Oral Cavity

The changes of drinking water (tap water) content and physicochemical properties affect the process of mineralization in the oral cavity. Two of the extrinsic factors that can change the pH level and concentration of ions in the environment surrounding the teeth are food and the liquids consumed by humans including tap water. Changes in the physiochemical properties of drinking water affect mineralized tissues in the oral cavity in two ways. Firstly, through their systemic impact on the mineral content calcium, magnesium fluoride, and phosphate homeostasis which is reflected in the concentration of these components secreted with saliva. Secondly, through their local impact on the tissue of teeth when drinking water and consuming food prepared on water base.[1]

One study, among 75 cities in the US showed a direct relationship between mineral content of drinking water especially the hardness (calcium, magnesium content) and its effect on the resistance and susceptibility of teeth to demineralization. It suggested that the highest hardness the lowest the number of decayed, missing, and filled tooth surface.[2]

Saliva pH and Dental Calculus Formation

The results of one study supported the hypothesis that an alkaline pH in plaque is critical in promoting plaque mineralization, and mineral deposition is modulated by serum. These factors are likely to be important in regulating calculus formation. In this study, it was found that calcium phosphate deposition was proportional to the plaque resting pH.[3] Furthermore, the pH level of saliva and its saturation with calcium and phosphate salts together with fluoride are important agents for promoting repair of mineralized tissue in the oral cavity in the process called remineralization.[4]

Oral Hygiene Habits and Dental Calculus

Individual oral hygiene practices are required to be regular and sufficient for a healthy dental and periodontal condition. While it is sufficient to interrupt individual oral hygiene practices for a short-term for the formation of soft accessories such as debris and bacterial plaque on tooth surfaces, a long-term negligence of the oral hygiene is required for the formation of calculus.[5] Following the professional prophylaxis, mineralization might emerge within a few days[6], and could become apparent in clinical presentation—which relatively resembles limestone—in some individuals within a short time like 2 weeks.[7]

Dental Calculus Composition and Definition

Dental calculus is primarily composed of mineral (inorganic) and organic (cellular and extracellular matrix) components. Supragingival and subgingival calculus contain 37% - 58% mineral content by volume, respectively.[8] The inorganic part consists primarily of calcium phosphate crystals organized into four principal mineral phases: ocatacalcium phosphate, hydroxyapetite, β –tricalcium phosphate or whitelockite. Brushite: dicalcium phosphate dehydrate (DCPD) is only present in the early stage of supragingival calculus.[9,10]

Calcium, Phosphate and Dental Calculus Formation

Calcium and phosphate are naturally present in water. They may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a dietary mineral that is present in the human body in amounts of about 1.2 kg .Calcium stabilizes the pH of the body. In order to stimulate this body function a daily intake of about 1000 mg of calcium is recommended for adults.[11] However, calcium and phosphate which are two salivary ions are "raw materials" for dental calculus formation. Together they form calcium phosphate $Ca_3(PO_4)_2$ that is the driving force of dental plaque mineralization thus dental calculus formation.[9,12] Both salivary flow rate and plaque pH appear to influence the saturation degree of calcium phosphates.[9] Plaque absorbs calcium and phosphate from saliva for the formation of supragingival calculus and from crevicular fluid for the formation of subgingival calculus. Calcium phosphate supersaturation, certain membrane- associated components, and the degradation of nucleation inhibitors are required for initial mineralization of plaque and bacteria.[10] More supragingival calculus occurs in the regions with the most exposure to saliva. In another word, calculus deposition tends to occur where plaque is exposed to a salivary film of high velocity.[9]

Fluoride and Dental Calculus Formation

Acid production by plaque bacteria can be inhibited by the presence of fluoride.[13] Fluoride may have the potential to increase the plaque pH which may be another mechanism by which fluoride inhibits demineralization and promotes remineralization of hard tissue.[9] Taken together, one can assume that fluoride present in saliva from the diet, toothpastes, and mouth rinses should be able to facilitate calculus formation. However, few studies or reports have shown that fluoride increases the prevalence or severity of dental calculus in humans. Instead, sodium fluoride may be able to inhibit the bacterial phosphatases and pyrophosphatases which are the enzymes well-known to promote calculus formation.[14] Moreover, fluoride has been found to curtail greatly or even eliminate the appearance of OCP (octacalcium phosphate) like precursor phases during spontaneous calcium phosphate precipitation.[9] Fluoridation may also affect indirectly on decreasing subgingival calculus accumulation and the periodontal tissue by reducing caries and the amount of restorative treatment.[15]

Magnesium and Dental Calculus Formation

Magnesium is the other hardness determinant in addition to calcium.[11] Magnesium inhibits the formation of dental calculus with its calcium channel blocking effect.[16] Also, it inhibits the formation of dental calculus by reducing and preventing the undesirable effects of phosphate in the sense of creating stones.[17] Magnesium inhibits apatite originating from amorphous calcium phosphate to the benefit of whitlockite formation. Therefore, magnesium inhibits the formation of calculus.[18] Finally, the healthy water association (HWA) standard calls for bottled water to provide a minimum of 25 mg of magnesium per liter and the ratio of calcium to magnesium in bottled water should not be greater than 2-to-1. Some researchers suggest a more balanced 50-50 ratio between calcium and magnesium in the diet where excessive calcium is a danger.[19]

MATERIALS AND METHODS

A clinical examination to 202 dental patients age from 16-40 years old 101 from Riyadh and 101 from Sharqiyah visiting dental hospitals was done using calculus index, and pH saliva test(using pH indicator papers full range) to define the exact pH range of the saliva (acidic, neutral, alkaline). Also, patients had to answer a questionnaire that included questions about: oral hygiene habits (flossing, brushing, mouthwash), the last time the patient had scaling at a dentist office,

dietary system, smoking habits, the type of drinking water (bottled, trucks, desalination tap water), and the amount of daily water consumption. Drinking water samples lab analysis was done for different drinking water sources: Desalination drinking tap water, trucks loaded water, and bottled water.

Lab water content analysis techniques used were:

I: Color mating spectrophotometer for detecting (PO_4^{3-})

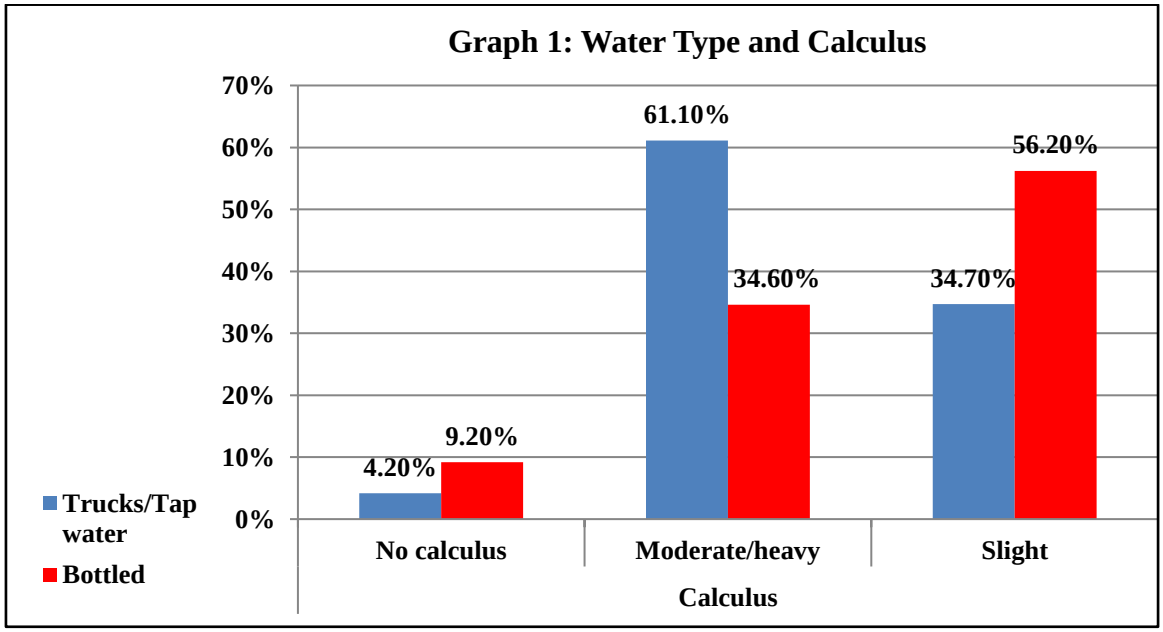
II: (ICP) Inductively coupled plasma emission spectrometer for detecting (Ca^{2+}).

A statistical analysis to the outcome of 202 patients selected randomly from the two provinces (Riyadh and Sharqiyah) was done using the test statistic $\chi 2$ Chi-square to test the association between categorical variables, and multinomial logistic regression to evaluate the relation between nominal dependent variable (calculus) and risk factors (provinces and type of water) for the purpose of a statistical analysis where we intended to calculate the odd ratio which compares the odd of moderate /heavy calculus vs. no calculus and the odd of slight calculus vs. no calculus for each of the above mentioned factors .

Table 1: Water type and calculus

Water Type+	P-value	Odd Ratio	95% Confidence Interval for Odd Ratio	
			Lower Bound	Upper Bound
Trucks/tap water Moderate/Heavy	0.04	3.91	1.03	14.8
No calculus*				
Trucks/tap water Slight	0.6	1.37	0.357	5.254
No calculus*				

* is reference group, + Bottled is reference group



RESULTS

Type of Drinking Water and Calculus

There is a statistically significant relationship between calculus severity and the type of drinking water (trucks/tap water, bottled) P-value= 0.001<0.05. The type of water (trucks/tap water, bottled) plays a statistically significant role in differentiating the patients who have (moderate /heavy) calculus from patients with no calculus patients P-value=0.04<0.05.

Patients who drink water from trucks/tap water are more likely to be at a four times higher risk to have calculus (moderate/heavy) than patients who get their drinking water from bottled with Odd Ratio = 3.91 (1.03,14.8). However, the type of water doesn't differentiate the patients who have slight calculus from patients with no calculus P-value =0.6 >0.05. Patients who drink water from trucks/tap water are more likely to be at a one-time higher risk to have slight calculus than patients who get their water from bottled with Odd Ratio= 1.37(0.357, 5.254). The model was significant P-value=0.001<0.05 and valid with classification accuracy= 58% which is greater than proportional by chance accuracy criteria 0.54 (1.25*0.435). Results are summarized in table 1.

There is difference between the two provinces with a significant P-value in the following three categories: Calculus Risk, Type of Drinking Water, and Saliva pH.

Calculus Risk

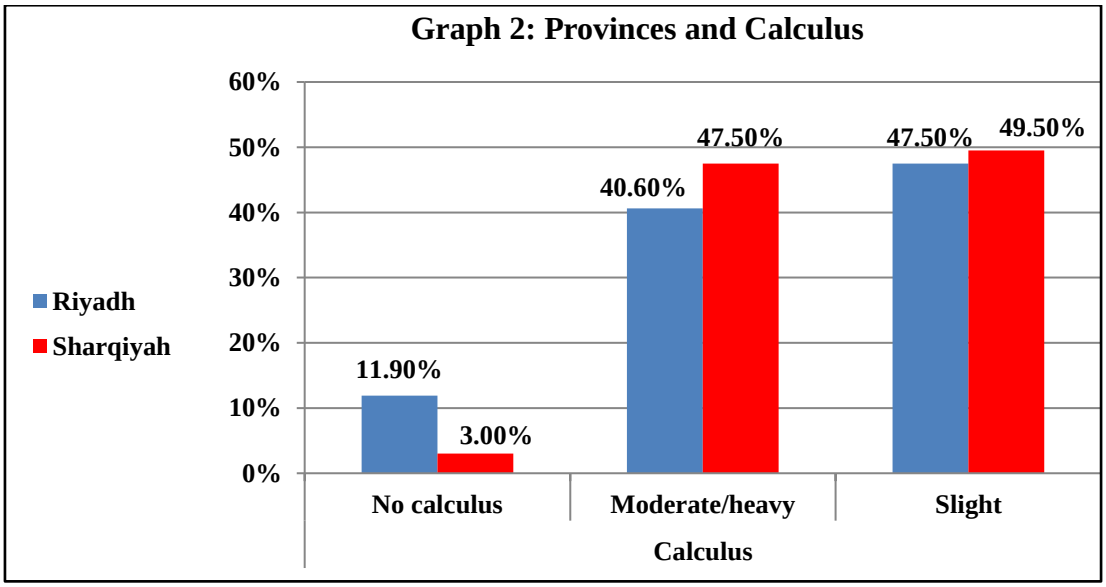
There is a statistically significant association between provinces (Riyadh- Sharqiyah) and calculus risk (no calculus, slight calculus, and moderate/heavy calculus) P-value=0.04 < 0.05. Provinces (Riyadh-Sharqiyah) play statistically significant role in differentiating the patients who have (moderate /heavy) calculus from patients with no calculus P-value=0.02< 0.05.

Provinces (Riyadh-Sharqiyah) play a statistically significant role in differentiating the patients who have slight calculus from patients with no calculus P-value=0.03< 0.05. Patients from Riyadh are less likely to have (moderate/heavy) calculus than Sharqiyah. Odd Ratio=0.214(0.056, 0.895) which means that Riyadh is 78.6% less likely-lower risk- to have (moderate/heavy) calculus. Patients from Riyadh are less likely to have slight calculus than Sharqiyah. Odd Ratio = 0.24(0.064, 0.904) which means that Riyadh is 76% less likely-lower risk- to have slight calculus. Results are summarized in table 2.

Table 2: Provinces and calculus

Provinces+	P-value	Odd Ratio	95% Confidence Interval for Odd Ratio	
			Lower Bound	Upper Bound
Riyadh Moderate/heavy No calculus*	0.02	0.214	0.056	0.895
Riyadh Slight No calculus*	0.03	0.24	0.064	0.904

* reference group , + reference group (Sharqiyah)



Saliva pH

Alkaline saliva pH which is a contributing factor to creating calculus is higher in Sharqiyah (41.6%) than Riyadh (19.8%), and there is a difference in the saliva pH between the two provinces with a highly significant P-value 0.002 <0.05.

Type of Drinking Water

There is a difference in the type of drinking water with a highly significant P-value=0.00<0.05 between the two provinces. The results show that Sharqiyah province depends more on trucks loaded water (53.5%) than bottled water (38.6%) with (7.9%) dependence on desalination tap water while Riyadh depends more on bottled water (90.1%) than trucks loaded water (9.9%) with a (0%) dependence on desalination tap water.

There is no difference between the two provinces in the following categories: Individual smoking habits, individual oral hygiene habits (frequency of brushing teeth per day, the last time the patient had scaling at a dentist office, and using mouthwash), and the number of glasses of drinking water consumed daily. The results in details are: There is no difference between Sharqiyah Province and Riyadh with insignificant P-value=0.06>0.05 concerning the frequency of brushing teeth per day. For instance, Sharqiyah province brushes teeth two times daily with a percentage (45.50%) that is too close to Riyadh (41.60%). In addition, there is no difference in using mouthwash P-value=0.4>0.05 "I don't use mouth wash" Riyadh (71.3%) Sharqiyah (66.3%). Also, there is no difference between Sharqiyah province and Riyadh with insignificant P-value=0.37>0.05 concerning the last time the patient visited the dentist office for scaling. Furthermore, there is no significant difference P-value=0.17>0.05 in the number of glasses of drinking water consumed daily. Finally, There is no difference between Sharqiyah province and Riyadh with insignificant P-value=0.1>0.05 concerning individual smoking habits "I don't smoke" Riyadh (81.2%) Sharqiyah (91.1%).

Desalination tap water whether provided directly by the government to homes in Sharqiyah province in particular Al Jubail (Ca^{2+})= 16 mg /L ppm and (PO_4^{3-})=0.1 mg/L ppm or coming from wells to taps in Al Hufouf and desalinated effectively with home devices (Ca^{2+})= 4.8 mg /L ppm and (PO_4^{3-})=0.1 mg/L ppm are safe for drinking consumption. Bottled water is safe for drinking consumption and has safe content of phosphate (PO_4^{3-}) ≤ 0.1 mg/L ppm, calcium (Ca^{2+}) ≤ 16.5 mg /L ppm, and magnesium (Mg^{2+}) ≤ 2.4 mg/L ppm. Trucks loaded water that isn't desalinated properly at home with an effective home device is a direct risk, and it is an essential contributing factor for calculus formation and accumulation due to the high content of calcium and phosphate the two driving forces for calculus formation and accumulation. (PO_4^{3-})= 0.3 mg/L ppm (Ca^{2+})= 87 mg /L ppm.

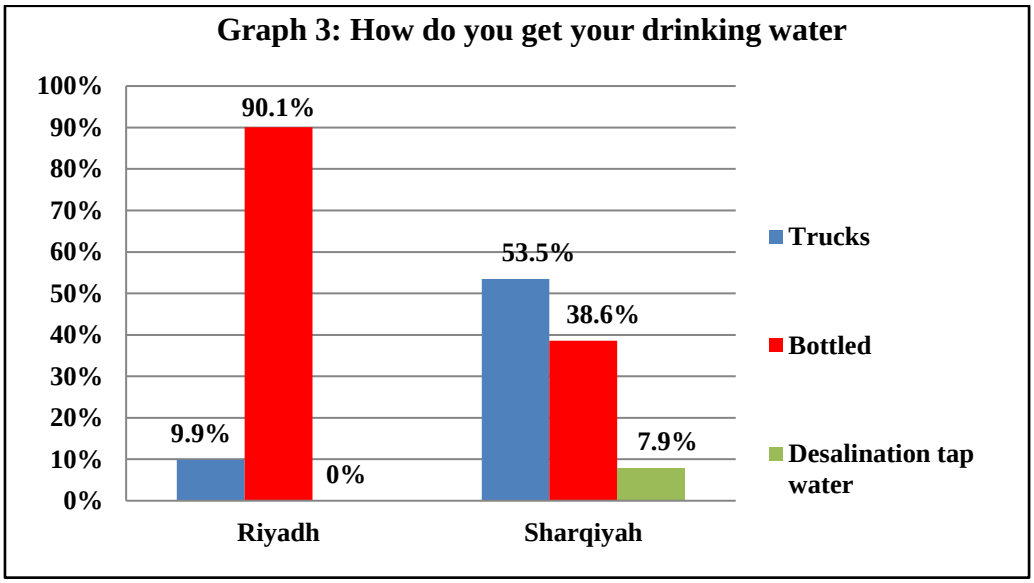
DISCUSSION

Calculus Risk

Using the test statistics Chi-square test to test the association between calculus (no calculus, slight, and moderate/heavy) and type of water in relation to Riyadh, there is no significant association between type of water and calculus in relation to Riyadh P-value=0.976 >0.05.

Using Chi-square test to test the association between calculus (no calculus, slight, and moderate/heavy) and type of water in relation to Sharqiyah, there is a highly significant association between type of water and calculus in relation to Sharqiyah P-value=0.000<0.05.

Using Chi-square test to test the association between (Riyadh, Sharqiyah) and how they get drinking water (bottled, trucks, and desalination tap water), there is a highly significant association P-value =0.00<0.05. Sharqiyah that has a higher calculus risk than Riyadh depends more on trucks loaded water and desalination tap water. Riyadh mainly depends on bottled drinking water .This fact along with the insignificant difference in oral hygiene habits between the two provinces, the insignificant association between calculus and type of water in relation to Riyadh, the highly significant association between calculus and type of water in relation to Sharqiyah, support the hypothesis that the type of drinking water helps in creating calculus.



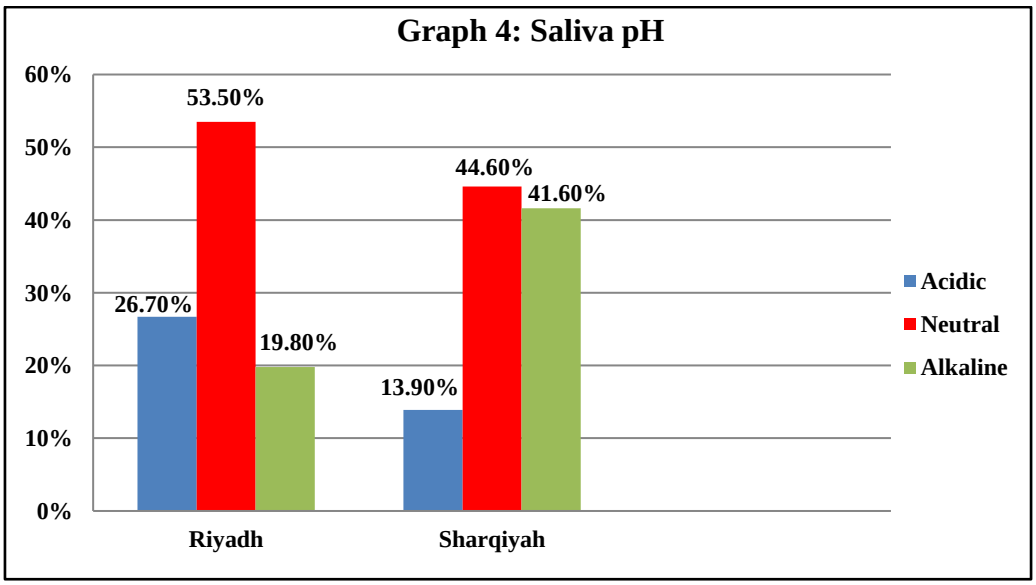


Table 3: Four samples of water lab analysis for(Ca^{2+})and(PO_4^{3-}) mg/L PPM

Sample ID	(PO_4^{3-}) mg/L PPM	(Ca^{2+}) mg/L PPM
Bottled Water	<0.1	16.5
Desalination (Tahliah) Al Jubail tap water Sharqiyah Province	0.1	16
Well tap water Al Hufouf with a desalination home device Sharqiyah Province	0.1	4.8
Trucks water from a water refill station (pipes come directly from Dammam Sea, the Arabian Gulf Sea)	0.3	87

(PO_4^{3-}) levels[20]:
0.01-0.03 mg/L-the level in uncontaminated lakes
0.025 – 0.1 mg/L-level at which plant growth is stimulated
0.1 mg/L-maximum acceptable to avoid accelerated eutrophication
>0.1 mg/L- high levels of phosphate in water. Accelerated growth and consequent problems.

Table 4: Descriptive comparative data for questions included in the questionnaire

Question	Riyadh The highest percentage choice only	Sharqiyah The highest percentage choice only	Significant or insignificant relation between variables
Do you use mouthwash?	No 71.3%	No 66.3%	Insignificant P-value=0.4
Is your dietary system balanced containing (vegetables, fruit, bread, legumes and dairy products)?	Yes 69.3%	I don't know 45.5%	Significant P-value=0.00
Are you a smoker?	No 81.2%	No 91.1%	Insignificant P-value=0.1
How many times do you use dental floss per week?	Never 63.4%	Never 72.5%	Significant P-value=0.001

Using Chi-square test to test the relation between Saliva pH and Provinces, there is a highly significant association between saliva pH and province P-value =0.002<0.05.Sharqiyah province has higher alkaline saliva than Riyadh with a percentage of (41.60%) in comparison to Riyadh (19.80%) which reflects a higher tendency to develop calculus in Sharqiyah. However, Acidic saliva is higher in Riyadh (26.70%) than Sharqiyah (13.90%) which reflects a tendency to develop dental caries in Riyadh.

Finally, There is a highly significant difference in the dietary system habits between the two provinces P-value=0.00<0.05 Riyadh "yes, my dietary system is balanced" (69.3%). Sharqiyah "I don't know if my dietary system is balanced" (45.5%). In this context, the aetiology of dental calculus formation is not fully understood, but it is known that a number of factors play a role. Generally, anthropologists have overlooked the role of other causative factors in the formation of dental calculus, attributing it almost exclusively to diet, particularly protein consumption. Anthropologists have also oversimplified the role of diet in the formation of dental calculus. This may be due to a general paucity on research on dietary effects on calculus formation, as well as a lack of integration between anthropological and non-anthropological data.[21]

CONCLUSION

The content of drinking water in the Kingdom of Saudi Arabia is a contributing factor that plays a role in forming and accumulating dental calculus depending on the source of drinking water concerning the levels of (Ca^{2+}), (PO_4^{3-}) , and (Mg^{2+}). Bottled water is the best in the Kingdom. Other kinds of tap water like the ones coming from wells and trucks loaded water supplied to houses are unsafe for drinking consumption purposes and need to be effectively desalinated and treated with effective desalination home devices then analyzed periodically before any drinking consumption to reach the safe content of (Ca^{2+}) and (PO_4^{3-}) taking into consideration the importance of magnesium (Mg^{2+}) and the ratio of calcium to magnesium which ideally should not be more than 2-to-1.[19]

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