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Review Article

Association between oral health and infant milk formula feeding - A clinical guide

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ABSTRACT:

According to health specialists breast milk is the healthiest nutritional choice for infants because they believe in a natural way for infants and new-borns to get the nutrition they need. The World Health Organization suggests exclusive breast feeding for at least six months. But breastfeeding may not be possible for all women due to health issues. Comfort level, lifestyle, and specific medical situations are the primary factors on which mother's decision to breastfeed or formula feed is based. For mothers who can't breastfeed or who choose not to, infant formula is a healthy alternative choice. The formula provides babies with the nutrients they need to grow and thrive. The use of baby formulas and bottles has inherent risks because they increase the risk of oral diseases, such as mouth breathing, malocclusion, alteration of bite, and tooth decay. Occurrence of ECC is largely influence by the feeding practices. Exploring the scientific literature for different types of infant formula and their role in the etiopathogenesis of dental caries could give us an insight into the cariogenic potential of infant formula. Understanding the role that breastfeeding and infant milk formula feeding by bottle play in the development of dental caries, dental fluorosis and malocclusion during childhood is essential in helping dentists and parents and care providers to prevent these conditions, and also for the development of effective public health policies. **Keywords:** growth, infant formula, nutrition

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INTRODUCTION

Early nutrition is critical to the development, growth, and health of children during infancy and early

childhood. It is estimated in 2006 that one-third of the 9.5 million deaths among children under the age of five years are due to inadequate nutrition.¹ A lack of nutrition can also result in obesity among children, which is a significant public health concern around the world. The best source for infant nutrition is regarded to be the mother's own milk.²According to the policy statement given by American Academy of Pediatrics breastfeeding appears to be necessary for infant's and children's healthy growth and development.³ Breast milk contains number of bioactive compounds that can affect gastrointestinal health, immune system function, and brain development. Breast milk is widely recognized as a biological fluid which is essential for an infant's healthy growth and development.⁴For mothers who can't breastfeed or

who choose not to, Infant milk formula (IMF) is a best functional alternative of breast milk but the use of baby formulas and bottles has inherent risks because they increase the risk of oral diseases, such as mouth breathing, malocclusion, alteration of bite, and tooth decay. The American Academy of Pediatric Dentistry (AAPD) states that perinatal and infant oral health is the foundations for building preventive education and dental carefor a child to have a lifetime free from preventable oral disease. Dentists, allied health professionals, physicians, and community organizations need to be partners to achieve this goal.⁵This review article is about the role of breastfeeding and infant milk formula feeding by bottle in the development of dental caries, dental fluorosis and malocclusion during childhood and some preventive measures which are helping dentists, parents and care providers to prevent these conditions, and also for the development of effective public health policies.

BREAST FEEDING AND DENTAL HEALTH

Breastfeeding helps in protecting against tooth decay for up to 12 months, according to two recent systematic reviews and metaanalysis.^{6,7}

Now in development of maxillofacial structures, stomatognathic structures are composed of both static and dynamic structures, whose functioning depends on the maintenance of a balance between them. It has been proven that functions comprised of the stomatognethic apparatus (sucking, respiration, speech, chewing, swallowing) contribute most to the development of the child's maxillofacial system and the position of the teeth in its arch.⁸⁻¹⁰

The onset of a malocclusion is strongly associated to some kind of eugnathic growth defect concerning the mandible, maxilla, and functional matrix to variable degrees (tongue and facial muscles).¹¹The newborn's suction reflex is his or her first coordinated muscle activity.A suction is either nutritive (breastfeeding or bottle-feeding) or non-nutritive.¹² The first one delivers nutrients to the infants, which are necessary for growth and development. Breastfeeding plays a key role in establishing an adequate lip seal, mandibular function, and tongue position against the palate, making it a cornerstone of normal maxillofacial development.¹³The tongue and facial muscles work synergistically to squeeze the milk out of the mother's breast during breastfeeding, but bottle-feeding requires less effort to drain the milk, thus understimulating the functional matrix.^{14,15}

Reduced or absent breastfeeding has been associated with the development of several malocclusions, such as skeletal class II,¹⁶ open bite,¹⁷ and posterior crossbite.^{18,19}Limeira et al.,¹⁸ discovered that no breastfeeding or minimal breastfeeding might be linked to posterior crossbite in the mixed dentition.In the primary dentition, a significant increase in posterior crossbite and a decrease in bite force has been reported if the baby was not breastfed or was breastfed for minimal period than 6 months, with the exception of Germa et al., 2016.14,18-20 Various studies have reached different conclusions about vertical discrepancy. It was discovered by Peres et al.,²¹ and Romero et al., 10 that having an anterior open bite was associated with breastfeeding in a short period of time or not at all.Moimaz et al.,22discovered that subjects who had been breastfed for more than a year had a higher prevalence of increased overbite and overjet. In contrast, Sum et al.,²³ were not able to determine a correlation between breastfeeding and vertical discrepancy. As to sagittal discrepancy, some studies found an association between longer breastfeeding andreduced overjet.^{21,23}Lopes-Freire et al.²⁴ on the other hand, were unable to find any link between these two variables.

INFANT MILK FORMULA

Infant milk formula (IMF) is a functional alternative for infants under the age of twelve months. All formulas are categorized using three criteria: calorie density, carbohydrate source, and protein composition.²⁵ The most important ingredient required for formulating IMF products are proteins, fats, and carbohydrates, while vitamins and minerals serves as micronutrients. Each stage of infant development requires a different composition of IMF powder. So that, IMF is categorized into three stages: stage 1 is for infants aged 0-6 months, stage 2 is for newborns aged 6-12 months, and stage 3 is for those older than a year. During the IMF powder production, the manufacturers can use a mixture of carbohydrates (European Commission, 2006), lactose is the primary component, which is critical to the physicochemical properties of the formula during processing as well as storage.²⁶Despite all efforts to bring IMF closer to human milk (HM), there is still a nutritional difference between the two, which affects physiological, newborns' neurological, and immunological growth and development.27,28

According to the World Health Organization (WHO) infants should be breastfed exclusively during the first six months of life, whereas the American Society of Paediatrics recommends that they should be breastfed for at least 12 months.²⁹However, only 38% of infants worldwide are breastfed,³⁰ resulting in \$41 billion business, according to the IMF.³¹In low- and middle-income countries, merely 37% of newborns under six months are exclusively breastfed, and the ratio is much lower in high-income countries.32 According to records from Chile's Department of Statistics and Health Information (DEIS), the exclusive BF (EBF) rate in the Public System at six months of life was 46% in 2005, and 50% in 2008; however, the most recent data for 2014 demonstrates only 44.5%. The goal was to achieve 60% EBF in six months by 2020.33

In some cases, breastfeeding is medically contraindicated or sometimes parents choose Infant milk formula feeding. The conditions are following:

HEALTH OF MOTHER

Mother is either HIV positive or has active TB. She is very sick or has undergone some types of breast surgery that might have removed or disconnected all of the breast milk-producing portions. She is taking any medicine that could harm the baby, including both prescription and illicit drugs like cytotoxic chemotherapy for cancer treatment.

BABY IS UNABLE TO BREASTFEED

Breastfeeding is difficult or impossible for the infant due to birth abnormality or inborn metabolic error such as galactosemia.³⁴

BABY IS CONSIDERED AT RISK FOR MALNUTRITION

Infants might be in danger due to malnutrition in specific circumstances, such as iron insufficiency, vitamin shortages (e.g., vitamin D, which may be less present in breast milk than required in high latitudes with limited sun exposure), or inadequate nutrition during the transition to solid foods.Improving the knowledge regarding diet of parents and guardians, along with the availability of macronutrients and micronutrients, can often reduce risks.In Canada, for example, marketed infant milk formulae are enriched with vitamin D, but Health Canada also suggest supplementing breastfed newborns with vitamin D.

PERSONAL PREFERENCES, BELIEFS, AND EXPERIENCES

Breast-feeding may be disliked or viewed as inconvenient by the mother. It can also be challenging for victims of rape or sexual assault; it might, for example, induce post-traumatic stress disorder.³⁵Many families chooses to bottle feed their children in order to boost the father's involvement in child's upbringing.³⁶

ABSENCE OF THE MOTHER

If the child is Adopted, orphaned, abandoned, or in the sole custody of a man or male same-sex spouse. While in prison or in mental institution, the mother is separated from her child. For a long period of time, such as while traveling or working overseas, the mother has left the child in the care of another person.

FOOD ALLERGIES

The mother consumes foods that may cause the infant to have an allergic reaction.

FINANCIAL PRESSURES

Maternity leave is unpaid, insufficient or not available at all. Breastfeeding is hampered by the mother's job so that they may see a decrease in their earning ability.³⁷

SOCIETAL STRUCTURE

Breastfeeding may be forbidden at the mother's job, school, place of worship or at other public places, or they may feel that breastfeeding in these places or around other people is immodest, unsanitary, or inappropriate.³⁷

SOCIAL PRESSURES

Family members, such as the mother's husband or other members of society may encourage the use of infant formula. For example, they may believe that breastfeeding will decrease the mother's energy, health, or attractiveness.

LACTATION INSUFFICIENCY

The mother is unable to produce sufficient milk. Alternatively, despite of healthy supply, the woman or her family may incorrectly believe that her breast milk is of low quality or low in supply. These women may choose infant formula either exclusively or as a supplement to breastfeeding.

FEAR OF EXPOSURE TO ENVIRONMENTAL CONTAMINANTS

Certain environmental pollutants, such as polychlorinated biphenyls, can bioaccumulate in the food chain and may be found in humans including mothers' breast milk.³⁸

LACK OF WET NURSES

Wet nursing is illegal and stigmatized in some countries, and may not be available. It may also be socially not unsupported, expensive, or health screening of wet nurses may not be available. The mother, her doctor or her family may not know that wet nursing is possible, or may believe that nursing by a relative or paid wet nurse is unhygienic.

In such a scenario Infant milk formulae (IMF) are an important source of nutrition supplements for nonbreastfed infants and an essential primary source of nutrition for non-breastfed infants in cases of early cessation of nursing.

COMMERCIALLY AVAILABLE INFANT MILK FORMULAS

HISTORICAL VIEW OF INFANT MILK FORMULA WHICH IS AVAILABLE IN THE UNITED STATES

COW-MILK-BASED FORMULAS

1867 – Formula contained wheat flour, cow milk, malt flour, and potassium bicarbonate

1915 – Formula contained cow milk, lactose, oleo oils, and vegetable oils; powdered form

1935 – Protein content of formula considered

1959 – Iron fortification introduced

1960 – Renal solute load considered; formula as a concentrated liquid

1962 - Whey: casein ratio similar to human milk

1984 – Taurine fortification introduced

Late 1990s - Nucleotide fortification introduced

Early 2000s – Long-chain polyunsaturated fatty-acid fortification introduced

NON-COW-MILK-BASED FORMULAS

1929 – Introduction of commercially available soy formula (soy flour)

Mid 1960s - Isolated soy protein introduced

Brands of Infant Milk Formula which are commercially available: Nestlé, Nan 1®, Pfizer, S26 1®, Pfizer, S26 Gold 1®, Aspen, Infacare Nurture 1®, Pharmac, Novolac 1®, Abbott, Similac Special Care 24Cal®, etc

INFANT MILK FORMULA AND DENTAL HEALTH

Certain cons should also be considered in using IMF. As it includes highly fermentable carbohydrates, infant formula is cariogenic, causing early childhood caries. Sucking, chewing, swallowing, and breathing are all functional stimuli that affect craniofacial growth and development.³⁹The growth and development of the maxilla-mandibular complex

have been linked to nutritive sucking, which includes nursing and bottle-feeding. Breast-feeding has been identified as one of the environmental elements that contribute to the proper development of teeth and other dentofacial structures in children.⁴⁰

CARIOGENIC POTENTIAL OF INFANT FORMULAS

IMF are often formulated with complex synthetic combinations of nutrients to achieve high caloric content, many of which includes high concentrations of fermentable carbohydrates such as sucrose, corn syrup, lactose, glucose polymers, and maltodextrin, which are highly cariogenic and have been implicated in the development of early childhood caries.⁴¹

Lactose, sucrose, maltose, and glucose make up the majority of the carbohydrates in infant milk formula. Lactose-free milk-based formulas can be replaced with sucrose-rich formulations. Depending on the serving size, the sugar content ranged from 1.28 to 11.16 grams. Some products have been discovered to have 12 grams of sugar per serving.Sucrose is the most cariogenic dietary carbohydrate whereas lactose is more difficult for S. mutans to ferment than sucrose. Several studies have been undertaken to cariogenic potential of infant assess the milk formulae which proved that Infant milk formulas have potential to induce demineralization and caries in primary enamel (Table 1).

 Table 1: Literature review of association between caries and Infant Milk Formula

Study	Methods	Inferences
Ericksonet al., 199842	Estimated the caries-	1. Plaque pH varied in response to oral rinsing with infant
	related risk associated	formula and most formulas did have the ability to reduce the
	with 26 infant formulas	pH significantly below the pH obtained after rinsing with
	and whole milk.	water
		2. Some infant formulas supported significant bacterial growth
		3. Enamel mineral was dissolved by incubation with certain
		infant formula
		4. The buffer capacity varied among the infant formulas tested
		5. The length of time required for caries to reach dentin or
		pulp differed for the formulas, with some formulas causing
		dentinal caries by 3.4 weeks and pulpal involvement by 7.2
10		weeks.
<u>Papa et al.,</u> 2012 ⁴³	Test: 10% sucrose	Both formulas induced significant enamel mineral loss, and
	solution; and milk-based	they were fermented, resulting in a decrease of biofilm pH,
	and soy-based formula	whether sucrose was added or not. Lactobacilli counts were
	with or without 10%	higher in biofilm formed in the presence of both formulas
	sucrose	compared to the water group.
	Control: distilled and	Milk and soy-based formulas have potential to induce
	deionized water	demineralization in primary enamel, which increased when
		sucrose is added.
<u>Aly</u> et al., 2020 ⁴⁴	human breast milk, plain	Enamel surface treated with breast milk has significantly
	infant formula or	increased mean calcium wt%, while no significant changes
	probiotic-containing	were detected in mean phosphate wt% whereas enamel
	infant formula compared	surface treated with plain or problotic-containing infant
	for the changes in	formulas, mean values of both calcium and phosphate wt%
	enamel mineral content	significantly decreased.
	of primary teeth	breast milk might confer some protective effect against
		enamer deminieransation, infant formulas whether plain or supplemented with some problems might premete loss of
		suppremement with some probloucs might promote loss of
		minerals from enamel surface.

EFFECT OF FLUORIDE CONTAINING INFANT MILK FORMULA

When utilized in systemic or topical formulations, fluoride has been proven to be a caries-preventative agent. According to research conducted in the United States, Australia, and Brazil, infant milk formula containsa higher proportion of fluoride.⁴¹Infant Milk Formula-fed infants had lower caries prevalence than non-formula-fed infants, according to several studies.^{44,45} Peres *et al.*,⁴⁶found that MS counts were greater in Wistar rats given fluoride-supplemented

infant milk formulae compared to human or cow's milk in research. This was ascribed to the infant formulae having a higher content of sucrose and lowering sugars.

On a per-body-weight basis,fluoride exposure for infants is approximately three to four times greater than adults when they are fed by infant milk formula reconstituted with fluoridated water.⁴⁷The amount of fluoride consumed by formula-fed infants in fluoridated areas is about 70 times that of exclusively breastfed infants.^{48,49}Thereforeenamel fluorosisis

more common in infant milk formula-fed infants than in breastfed infants.Excess fluoride exposure throughout the first four years of life causes enamel fluorosis⁵⁰but the first 12 months are the most susceptible.Despite the limited amount of fluoride transferred from plasma into breast milk, its fluoride concentration is extremely low (0.005-0.01 mg/L).48 In the United States and Canada, 25% of mothers report exclusively nursing for six months, as suggested by current practice guidelines. 90% of bottle-fed infants are given powdered formula and out of them 75% of mothers report they reconstitute infant milk formula with tap water containing higher levels of fluoride.⁴⁷Therefore, this reconstituted infant milk formula is the primary source of nutrition for many infants in the United States and Canada. There is no research investigating the potential neurotoxicity of using optimally fluoridated drinking water to reconstitute formula during childhood despite growing concerns about excessive fluoride exposure during childhood and the sensitivity of the developing brain.^{51,52} In two birth cohort studies,^{53,54} as well as other recent studies conducted in endemic fluorosis,55-57 and a 2012 meta-analysis58 of 27 ecologic investigationsincreased fluoride exposure during foetal brain development was linked to lower IQ scores. Increased fluoride exposure in children has also been linked to behaviours associated with ADHD in them.59,60

If infants younger than 6 months are exclusively fed infant milk formula reconstituted with fluoridated tap water, their fluoride intake may exceed the tolerable upper limits. Christine Till et al.,47 discovered that fluoride exposure during infancy predicts lower nonverbal intelligence in children after correcting for foetal exposure. The American Dental Association urges parents to reconstitute concentrate infant formulae with properly fluoridated drinking water while being aware of the danger of mild enamel fluorosis developing.⁶¹The Centres for Disease Control and Prevention (Community Water Fluoridation Infant Formula), as well as the US Department of Health and Human Services (2015), support this recommendation. When the fluoride level in drinking water is over the acceptable level, the Canadian Dental Association (2019) recommends using water with a reduced fluoride content (or ready-to-feed formula).⁴⁷ Fluoride's positive benefits are primarily seen on the tooth surface once teeth have erupted.⁶² Fluoride contributes to the prevention of dental caries primarily when it is topically applied to teeth, such as brushing with fluoridated toothpaste.⁶²⁻⁶⁴During foetal development or the first six months of life before teeth have erupted there is no recommended dosage for fluoride consumption according to Scientific Committee on Health and Environmental Risks (SCHER) because fluoride is not essential for growth and development.⁴⁷ As a result, the Canadian Pediatric Society advises only giving supplemental fluoride (i.e. systemic exposure) when the child's primary teeth begin to erupt (approximately 6 months) and only if the child is susceptible to high caries activity and has not been exposed to other fluoride-based interventions such as tooth brushing or water fluoridation.

CARIES PREVENTION IN INFANT MILK FORMULA-FED CHILDREN

- Keep your baby's mouth clean from birth to 12 months by gently cleaning the gums with a clean baby washcloth.
- Brush carefully with a soft baby toothbrush and a smear (grain of rice) of fluoride toothpaste after you notice the first teeth.
- Brush your child's teeth twice a day for two minutes between the ages of 12 and 36 months. Apply a smear of fluoride toothpaste to your child's teeth until the age of three.
- Brushing should be done after a morning feeding and before bedtime.
- Never put a bottle or food in your child's bed. This not only exposes your child's teeth to sugar but also puts him or her in danger of ear infections and choking.
- Use cups rather than bottles for feeding children with infant milk formula to prevent early childhood caries.

Tooth wipes are indicated as an important tool for dental hygiene care in infants and toddlers by the American Academy of Pediatric Dentistry (2008). Both parents and newborns acknowledge that using xylitol wipes is safe and acceptable.⁶⁵When compared to wipes without xylitol, the daily application of xylitol-containing wipes significantly reduced the incidence of caries among young children.⁶⁶

INFANT FORMULA – BOTTLE FEEDING ALTERATION OF THE ORAL CAVITY

As a child grows, use of a bottle interferes with the development of oral functions like abnormal swallowing. mouth breathing. masticatory dysfunction, phono-articulation issues, and a change in body posture etc. As a result of mouth breathing, there are more chances of inadequate ventilation, respiratory infections, impaired hearing, altered thoracic and body posture development, and changed maxillofacial development.33The biomechanics of milk extraction during breastfeeding has recently been researched in depth. Researchers analysed ultrasound (US) videos taken during breastfeeding and concluded that the periodic motion of the infant's jaws, the undulation of the tongue, and the breastmilk ejection reflex are all required for this difficult activity.⁶⁷According to another study, milk extraction during breastfeeding produced time-varying subatmospheric pressures within the infant's oral cavity, with vacuum pressures as low as -145 mmHg.⁶⁸The sucking mechanism utilized for bottle-feeding differs significantly from that utilized when breastfeeding.^{69,70}In contrast to breastfeeding, bottlefeeding involves less forceful muscle action and is therefore less effective in enhancing mandibular development. This discrepancy may predispose children who are bottle-fed for an extended period of time to malocclusion or other occlusion abnormalities.⁶⁹

So if a child is on infant milk formula feeding by bottle, he or she will perform less oral exercises, which can lead to muscle underdevelopment, incorrect lip and tongue posture, and the adoption of harmful oral habits, all of which can contribute to dental malocclusions.⁴⁰In children who were bottlefed infant milk formula for 6 to 18 months or longer than 18 months, a non-mesial terminal plane and a class II canine relationship were more prevalent.⁷¹

PREVENTION OF MALOCCLUSION

Various Bottle positions and various modifications in nipple and bottles are tried for their effect on jaw development.

The traditional bottle's overall structure allows the three types of bottle-feeding positions.

Position A - Bottle held perpendicular to the mouth, It is the most recommended position for IMF bottle feeding. It is the most likely alternative for preventing malocclusions because it applies balanced pressure to the maxilla and mandible, promoting proper sagittal plane jaw and tooth growth. (Fig.1) With position A children develop Class I occlusion with an overbite of 2 mm and an overjet of 1.5 mm. **Position B**–Bottle tilted at an upward angle.

Most of the parents have fed the child mainly in position B attempting to reduce air intake when the child is feeding. But this position can lead to an anterior crossbite, by retroclining themaxillary incisors and proclining the mandibular incisors, or promoting a forward posture of the jaw by the pressure of the nipple and cause malocclusion (Fig 2), So that it is not recommended for feeding and to reduce the air intake while feeding parents can use different type of bottles and nipples (Fig 4).

Position C - Bottle tilted at a downward angle This position is mainly use to procline the maxillary incisors and retrocline the mandibular incisors which is caused by bottle feeding with position B (Fig 3).⁷²



Figure 1: Position A - Bottle held perpendicular to the mouth. Figure 2: Position B – Bottle tilted at an upward angle. Figure 3: Position C - Bottle tilted at a downward angle



Figure 4: Different type of bottles and nipples

CONCLUSION

Breastfeeding is the best source of nutrition for most babies, and it should always be encouraged, supported, and protected. Infant formula should be chosen based on the infant's unique needs and medical condition in rare circumstances, such as galactosemia or primary lactase deficiency, or for any other medical reason if the mother is unable or unwilling to breastfeed. From birth until complementary feeding begins, infant feed, whether human milk or formula, is critical. Breastfeeding is more successful than bottle feeding for reducing dental caries in young children, according to existing scientific evidence. So that educational programs can be formed to inform and encourage parents of infants who are fed infant milk formula to clean their children's gums with a clean baby washcloth or xylitol wipes, and to teach them when and how to use fluoridated toothpaste for optimal dental hygiene.

Poor mandibular development may be caused by prolonged bottle-feeding, which may lead to occlusofacial disorders. If the hypothesis about bottle positioning during feeding is validated, educational programs to teach and encourage parents to utilize optimal bottle positioning during feeding can be implemented. Practitioners can rectify growing occlusions early on, letting patients to avoid or lessen the need for costly, time-consuming, and painful orthodontic procedures. For children who are on IMF feeding, proper bottle positioning can help a child's facial aesthetics, which can help them develop psychologically, socially, and emotionally.

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