Evaluation of Nickel Release in Blood and Periodontal Tissue with the Use of NiTi Wires, Bands and Brackets in Orthodontics – A Systematic Review

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ABSTRACT

BACKGROUND
It is of outmost importance to know the effects of nickel on a cellular level. The objective of this systematic review was to analyse the factors affecting nickel release, the amount of nickel being released in commercially available NiTi wires and to also analyse the blood / periodontal evaluation after orthodontic treatment in conventional and nickel free brackets.

METHODS
For this systematic review, relevant articles were searched in PubMed, MedLine, Cochrane, EMBASE and Google Scholar databases, along with a complimentary manual search of all orthodontic journals from January 1980 till the year 2019 December. The study included in vitro and in vivo studies. 14 articles were included in this systematic review.

RESULTS
160 articles were obtained initially. 41 were obtained by a manual search. 186 articles were excluded based on the inclusion criteria and 14 articles were found to be eligible.

CONCLUSION
This systematic review shows that nickel solution at a minimal concentration could damage human gingival fibroblast. As the carcinogenic effect of nickel has been already confirmed, other alloys that do not contain the heavy metal nickel can be used or standardization of the amount of nickel leach out from the appliance should be considered.

KEY WORDS
NiTi, Nickel Release, Periodontal Tissue or Periodontium, Cytotoxicity, Orthodontics

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BACKGROUND

Nickel was discovered by Axel Fredrik Crontedt in Sweden in 1751. It is from the German word "Kupernickel," meaning devils copper or St Nicholas Copper. Nickel [Ni] and chromium [Cr] containing alloys are present in a wide variety of appliances, auxiliaries, and utilities used in orthodontics and thus have become an integral part of routine orthodontic intervention.[1] Nickel is the most common cause of metal-induced allergic content dermatitis in human beings and produces more allergic reaction than all other metals combined. Second in frequency is chromium. Various appliances like the maxillary expansion appliance, lingual arches stay in mouth for a very long period of time. A minimum of 13 months of appliance wear is considered necessary for visualizing effects. Lingual arches which are commonly used as space maintainers are given to the patient from a very young age of 6 years until 13 - 14 years when the orthodontic treatment is completed. Hence it is utmost important to dwell upon the cellular effects. The oral cavity is a complete corrosion centre, with many factors that enhance the biodegradation of the orthodontic appliances.[2-4] The conventional orthodontic appliances consist of orthodontic bands, brackets, and arch wires, which were introduced in 1930s. Since then the alloys have become an invaluable material in orthodontics, which are made of stainless steel containing 8-12 % nickel, 17-22 % chromium, and various proportions of manganese, copper, titanium, and iron.[2] These are extremely durable and relatively inexpensive. The combination of the alloy materials is near each other, and in hostile conditions leading to corrosion and adverse reaction biologically and increases the friction mechanically. When using nickel titanium (NiTi) arch wire for dental orthodontic treatment, the possible danger associated with arch wire corrosion derives from the biologically harmful effects due to the released Ni ion.[5,6] Therefore, NiTi arch wire with a good corrosion resistance is crucial to its biocompatibility. On the other hand, the surface corrosion of NiTi arch wires may increase the friction that appears at the interface between the arch wire and bracket, reducing the free sliding action during orthodontic treatment. Various in vitro and in vivo methods have been carried out to evaluate the release of metals and their contents in saliva and blood. From these studies, it is concluded that metal released from the conventional appliances in saliva and blood samples were well below the average dietary intake and did not reach the toxic concentrations. It should be kept in mind that we cannot exclude the fact that even non-toxic concentration might be enough to induce effects in cells of oral mucosa.[4,5] There have been many studies that were carried out to evaluate the nickel release. However, there is no standardization regarding the amount of nickel that can be leached as the carcinogenic effect of the nickel has been proved. The cause and effect of this on human have never been demonstrated except that few studies show that there is DNA damage in mucosa cells. Saliva acts as an electrolyte for electron and ion conduction, and the fluctuation of pH and temperature, enzymatic and microbial activity, and the various chemicals introduced into the oral cavity through food and drink as corrosion conductors.[7-9] Factors affecting nickel release can be broadly classified as the following: pH of saliva, shape and dimension of wire, surface roughness and friction, galvanic corrosion within brackets and arch wires, time duration, based on manufacturers and products, and fluoride dentifrices from tooth pastes, while age and sex are not a prominent factor.[10-18] Hence, the objective of this systematic review is to analyse the factors affecting nickel release, the amount of nickel being released in commercially available NiTi wires and to also analyse the blood / periodontal evaluation after orthodontic treatment in conventional and nickel free brackets.

METHODS

Search Strategy

The research question was "Nickel release in various commercially available Niti wires and brackets and the factors influencing its release." Databases included in the search: PubMed, MedLine, Cochrane, Google Scholar, Embase, Science Direct and a complimentary individual journal search.

A complimentary manual search was also done in various orthodontic journals that included World Journal of Orthodontics, American Journal of Orthodontics and Dentofacial Orthopaedics, European Journal of Orthodontics, Journal of Clinical orthodontics and Angle orthodontics. The articles included in this review were over a span of 24 years, from 1980 till 2019. The following mesh words and key words along with Boolean operators were used: (((((((nickel) and nickel in nickel titanium wires) and ((blood and periodontal evaluation))) or nickel in blood) and nickel titanium wires used in orthodontics) or fixed orthodontic therapy) or nickel titanium wires in fixed orthodontic therapy) and nickel release in blood) and nickel release in periodontium. The number of articles obtained are given in Table 1.

Sl. No.	Database	Search terms	Articles found
1	PubMed central (Advanced search)	(((((((nickel) AND nickel in nickel titanium wires) AND ((blood and periodontal evaluation))) OR nickel in blood) AND nickel titanium wires used in orthodontics) OR fixed orthodontic therapy) OR nickel titanium wires in fixed orthodontic therapy) AND nickel release in blood) AND nickel release in periodontium	41
2	MedLine	(((((((nickel) AND nickel in nickel titanium wires) AND ((blood and periodontal evaluation))) OR nickel in blood) AND nickel titanium wires used in orthodontics) OR fixed orthodontic therapy) OR nickel titanium wires in fixed orthodontic therapy) AND nickel release in blood) AND nickel release in periodontium	25
3	Cochrane	(nickel in nickel titanium wires) AND (blood and periodontal evaluation) AND (nickel titanium wires used in orthodontics) AND (nickel release in blood) AND (nickel release in periodontium)	0
4	Google Scholar	(((((((nickel) AND nickel in nickel titanium wires) AND ((blood and periodontal evaluation))) OR nickel in blood) AND nickel titanium wires used in orthodontics) OR fixed orthodontic therapy) OR nickel titanium wires in fixed orthodontic therapy) AND nickel release in blood) AND nickel release in periodontium	61
5	EMBASE	(nickel in nickel titanium wires) AND (blood and periodontal evaluation) AND (nickel titanium wires used in orthodontics) AND (nickel release in blood) AND (nickel release in periodontium)	0
6	Science Direct	(nickel in nickel titanium wires) AND (blood and periodontal evaluation) AND (nickel titanium wires used in orthodontics) AND (nickel release in blood) AND (nickel release in periodontium)	33
7	Complimentary individual journal search	Evaluation of nickel release and blood and periodontal tissue with the use of NiTi wires in orthodontics	41

Table 1. Search Database

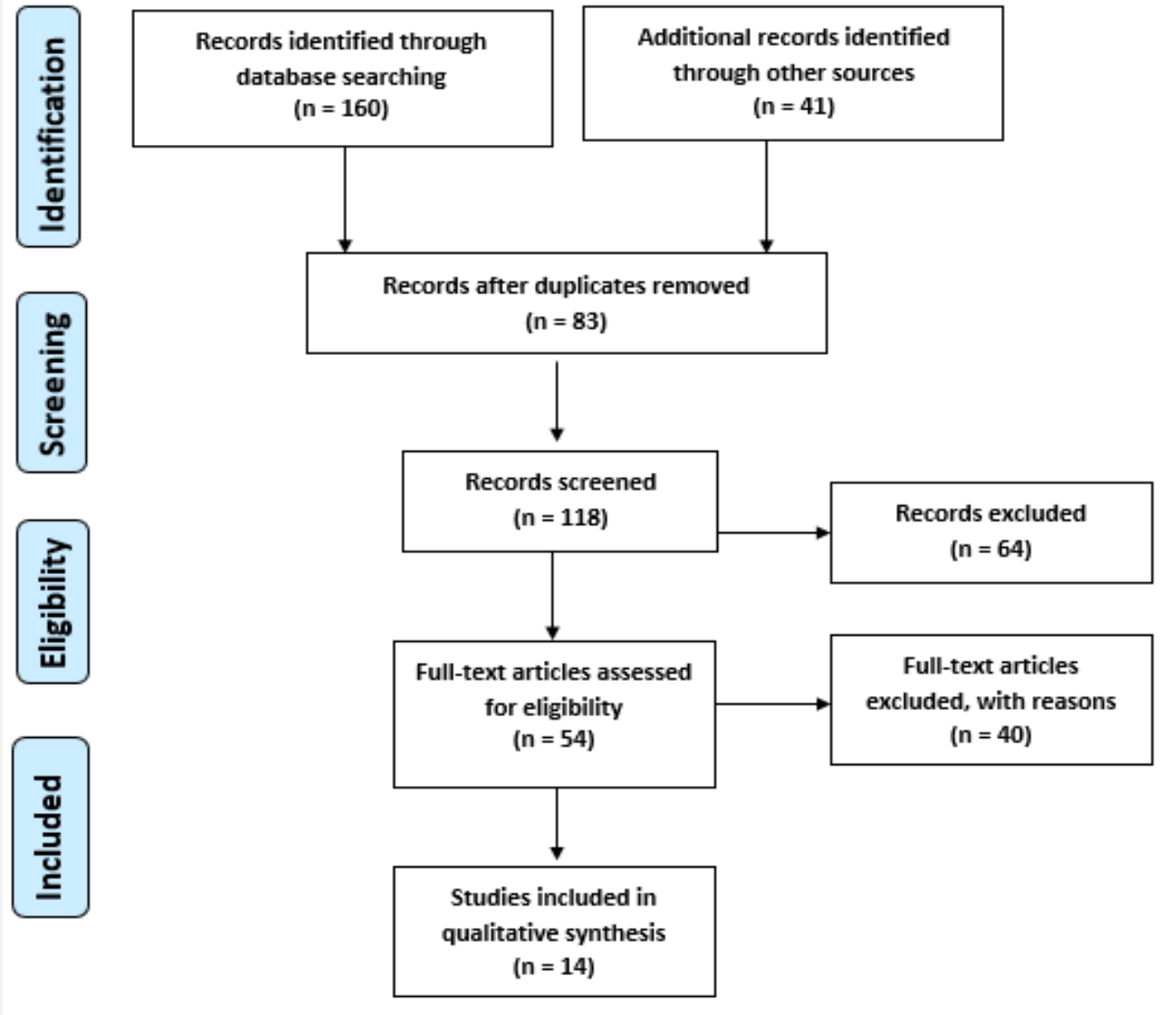

Table 2: Flow Chart

In vivo and in vitro articles, where studies on Niti wires were conducted, dated from 1980 till 2019 were included in the study. Articles that described the various amounts of nickel released from various wires used in orthodontic treatment were identified. Review articles and case reports were excluded. (Table 2)

Data Extraction

Data extraction was done by two reviewers. Studies that did not meet the inclusion criteria were not selected. Author, Year, Location, Type of Study, Participants (n), M / F (n), and Age (Years) Source of nickel (bracket / arch wire / band),

Characteristics of the attachment used such as slot/dimension of the arch wire etc, duration of time in the oral cavity, outcome, any other details from the article that can be recorded, was tabulated. (Table 3, 4 and 5) The articles selected were assessed for the risk of bias and were tabulated. This was done to check the quality of articles that were selected. (Table 6).

RESULTS

160 articles were obtained initially. 41 were obtained by a manual search. 186 articles were excluded based on its relevance to the search, case reports, reviews, short studies were also excluded. 14 articles were found to be eligible based on the selected criteria. The articles included were all in vitro studies. (Table 2, Table 3).

Factors Affecting Nickel Release - (Table 3)

Park & Shearer also measured the release of nickel and chromium from the simulated orthodontic appliances by atomic absorption spectrophotometry in-vitro, and reported that the average release for nickel was 40mic.gm/day. Nickel release depends on the pH of saliva and time duration in the oral cavity, characteristics of the wire [dimensions, surface roughness] pH of saliva: The increase or decrease in the pH of the saliva has a direct correlation with the amount of nickel that leaches out of the wire. Theodore [2002], determined the amount of nickel and chromium released in artificial saliva at varying values of pH 5 to 8 using atomic absorption

spectrophotometer. Results showed that decrease on pH caused an increase in nickel & chromium release levels.[5] Time duration: Time duration affects the amount of nickel release, where the amount of nickel release is more at the initial hours and gradually decreases. Barrett & Co-workers [1993], compared in vitro the corrosion rate of nickel and chromium from a standard orthodontic appliance consisting of bands, brackets and either stainless steel or nickel titanium arch wires. Samples were taken on days 1, 7, 14, 21 and 28 and were analysed using atomic absorption spectrophotometry. Their result indicated that the nickel release reaches a maximum after 1 week, then the rate of release diminishes over time. On the other hand, chromium release increases during the first 2 weeks and levels off during the subsequent 2 weeks.[10] Characteristics of the wire [dimensions, surface roughness].

Dimension of the wire has a direct correlation as well, larger the dimension of the wire, the more amount of nickel leaches out. Increase in the amount of surface roughness, increases the amount of nickel release.

Nickel Release in Various Commercially Available NiTi Wires - (Table 4)

Nickel ion release differs for NiTi arch wires from different manufacturers. It differs with difference in surface characterization. Wires with a rough surface, release more nickel ion into the oral cavity than a smooth surface. Nickel ion release into the saliva could cause cytotoxicity or genotoxicity or mutagenic effects. So, different modifications were made in NiTi wires for reduction in nickel ion release.[19]Ion implanted nickel-titanium arch wires form amorphous surface layer when bombarded with nitrogen ions. This layer gives corrosion resistance by replacing nickel ions.

Other type of alteration is by coating the arch wire with plastic or resin [like epoxy coated NiTi] or by adding Cu [CuNiTi]. CuNiTi arch wires show less release of nickel ion when compared to conventional NiTi wires, however still more than stainless steel arch wires. When used along with MIM brackets, epoxy coated NiTi and CuNiTi has less time dependent discharge of nickel ion. Nickel ion release from NiTi wire can be reduced by different means. On comparing the nickel ion release between conventional NiTi, copper NiTi and multi-stranded NiTi, conventional Niti released nickel the most in as received state and multi-stranded NiTi after oral stimulation. In both states, CuNiTi had the least nickel discharge.[20] Though the quantity of nickel ion release is less than the toxic limit, it might cause allergic reaction in a sensitized population. In such cases, there are alternate options like TMA wires, twist flex stainless steel, fibre-reinforced composite arch wires, pure titanium and gold-plated arch wires. It is seen that nitinol wires with the thickest surface oxide TiO2 [up to 720 nM] showed the highest nickel release, which can be explained due to the presence of essentially pure nickel.[1,3]

Sl. No.	Author, Year, and Location	Type of Study	Participants (n), M / F (n), and Age (Years)	Source of Nickel (bracket / arch wire / ...)	Characteristics of the Attachment Used Such as Slot/Dimension of the Arch Wire etc	Duration of Time in the Oral Cavity	Outcome	Any Other Details from the Article That Can be Recorded
1	Theodore Eliade's et al. 2004, AO, Greece	In vivo	45, no sex prevalence, no age range. 45 retrieved wires from patients	NiTi and arch formed SS wires	Pre formed arch wires, 16*22 rectangular were ligated to 0.018 slot SS brackets, by means of ligature wires or modules	4 months	No statistical difference in the Ni amount between as received and retrieved wires	SEM was used to assess the elemental composition of the wire after intra oral exposure
2	E. Espinar et al. 2011, France	In vitro	10 NiTi arch wires,	NiTi arch wire	Pre formed arch wires	Wires were oxidised to see if a homogenous layer was being formed	20 nm thick layer was nickel free after oxidisation	
3.	Huma D, Sreedevi D, Ajith; 2016; JOBCR; India	In vitro	50 simulated ortho appliances,	Niti and SS arch wire	Simulated ortho appliances, half an arch, 5 groups.	3 months	Highest amount of nickel was released from NiTi wires	
4.	Barat, Farzaneh, Berahman, Samaneh; 2014, Iran	In vitro	120, 40 in each group. single stranded NiTi, multi stranded NiTi, copper NiTi	Arch wires	0.016 round wires	2 months in an artificial salivary environment	Single stranded NiTi released most amount of Ni, followed by multi stranded	Cupper NiTi released the least amount of nickel
5.	Visnja et al. 2017, Croatia	In vitro	3 pre formed arch wires, artificial saliva	Arch wires	0.508*0.508mm arch wires, NiTi with untreated surface, rhodium coated NiTi and nitride coated NTti	28 days (3,7,14,21,28 days)	Ni ion release was maximum from NiTi with un treated surface	Hydrofluoric acid concentration predicts the release of Ni ions.
6.	Vinoth kumar at al. 2016, India	In vivo	10 patients, 14 - 23 years of age,	Arch wires and FA (SS brackets)	0.016 NiTi wire, 0.022 slot brackets	1 month (0, 10 d and 1 m)	Levels of Ni was stat significant with a gradual increase in 10 days and a decrease after	Significant Chromium levels were detected on the 30th day
7.	Shabalovskaya et al. 2008, Ireland	In vitro	3 wires, Nitinol	0.075 mm diameter Nitinol wires	0.075 mm diameter Nitinol wires (wire 1 and 2 were drawn using synthetic poly crystalline diamond dies, wire 3 was drawn using single crystal natural diamond	5 months	Significant levels of nickel released from all 3 wires	Significant amount of nickel was released even if the surface layers of wires were adjusted
8	Arash Azizi et al. Iran, 2016	In vitro	40 round wires and 40 rectangular wires	Arch wires	0.020-inch round NiTi wire and 16*16" rectangular NiTi wire	21 days in artificial saliva (1 h, 24 h, 1 w and 3 w)	Higher Ni ion release from rectangular wires	
9	Barrett et al. USA, 1993, AJODO	In vitro	10 sets	Brackets and arch wires	17*25" rectangular NiTi wire (5 nos) and SS wire used (5 nos).	28 days (1, 7, 14, 21 and 28)	Significant amounts of Ni and Cr were released in the 1st week. Amount of Ni release was 37 times greater than that of Cr	Increased amounts of Cr were released in the second week.

Table 3. Factors Affecting Nickel Release

Sl. No.	Author, Year, and Location	Type of Study	Participants (n), M / F (n), and Age (Years)	Source of Nickel (bracket / arch wire /)	Characteristics of the Attachment Used Such as Slot/Dimension of the Arch Wire etc	Duration of Time in the Oral Cavity	Outcome	Any Other Details from the Article That Can be Recorded
1	Gopikrishnan, Anil, Ajith and Binoy; 2014, India	In vitro	4 wires	4 arch wires,	17*25" SS, NiTi, TMA, copper NiTi wires	28 days in artificial saliva (7, 14, 21, 28)	Ni ion release along with chromium and iron from SS, CuNiTi and NiTi	Least to none from TMA
2	Huma, Sreedevi, Prachi; 2016, India	In vitro	50 samples	Simulated FA, and arch wires	4 types of wires. A – control B&C – SS wire D&E – NiTi and CuNiTi resp 16*22"	3 months (1 day, 7 days, 1 m, 2 m and 3 m)	Ni ion release was maximum at the end of 1st month. Non-significant difference at the end of 3 months	More nickel release from NiTi wires
3	Arash Azizi et al. Iran, 2016	In vitro	40 round wires and 40 rectangular wires	Arch wires	0.020-inch round NiTi wire and 16*16" rectangular NiTi wire	21 days in artificial saliva (1 h, 24 h, 1 w and 3 w)	Higher Ni ion release from rectangular wires	
4	Rabindra S Nayak et al. 2015, India	In vivo	30 patients, saliva sample was taken prior and 10 - 12 months after initial arch wire placement, 13 - 30 years of age	0.022 MBT SS brackets and arch wires	0.014, 0.016 NiTi 17*25, 19*25 heat activated NiTi, 17*25, 19*25 NiTi	10-12 months	Significant Ni ion concentration in the saliva after initial alignment	Significant amounts of chromium were also detected
5	Mashallah et al. 2016, Iran	In vivo	42 patients, 13 - 27 years of age	0.022 MBT slot, SS brackets and arch wires	0.014" Niti, 0.014" CuNiti and 0.014" Epoxy Niti	2 months	High Ni ion concentration in the saliva in patients in Grp A, and least in Group C	
6	Huang et al. 2003, Taiwan	In vitro	4 wires were immersed in artificial saliva	Preformed wires in artificial saliva	0.016 round Niti – Ormco, RMO, KH and SY companies = 4 wires	28 days (1, 7, 14, 21, 28)	All wires released similar amounts of Ni ion, with a constant increase over the time period, but not significant enough to worry about.	

Table 4. Nickel Release in Various Commercially Available NiTi Wires

Sl. No.	Author, Year, and Location	Type of Study	Participants (n), M / F (n), and Age (Years)	Source of Nickel (bracket / arch wire / ...)	Characteristics of the Attachment Used Such as Slot/Dimension of the Arch Wire etc	Duration of Time in the Oral Cavity	Outcome	Any Other Details from the Article That Can be Recorded
1	Camilla et al. 2016, Brazil	In vivo	42, 28 females and 14 males, 10 - 45 years of age	Conventional braces and nickel free braces	Patients underwent FA Rx for 12 months; patch test was done at regular intervals.	12 months (0,3,6,9, 12 and 1 month after removal of braces)	Patients treated with nickel free braces, had better gingival health and smaller blood changes	All abnormalities tended to be eliminated after removal of braces

Table 5. Blood and Periodontal Evaluation after Orthodontic Treatment in Conventional and Nickel Free Brackets

Articles	Theodore et al. [5]	E.Espinar et al.[14]	Barat et al.[8]	Visnja et al. [4]	Vinoth kumar et al.[7]	Shabalovskaya et al.[13]	Arash Azizi et al.[3]	Barrett et al.[10]	Gopi Krishnan et al.[16]	Huma et al.[12]	Rabindra S Nayak et al.[1]	Mashallah et al.	Huang et al.[20]	Camila et al.[21]
Sample size calculation	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Representativeness of orthodontic patients	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓	✗	✓
Selection of the orthodontic control group	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓
Assessment of nickel release	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Outcome of interest not present at the start	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓
Assessors qualified to provide results	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Description of inclusion / exclusion criteria	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓	✗	✓
Comparability of groups on the basis of the design	✓	✗	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✗
Assessment of factors that could influence outcome	✓	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓
Is the technique of Assessment correct	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Definitions and assessment of nickel release clearly reported	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adequacy of follow-up of patients	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓	✗	✓
Validity of statistical analysis	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Risk of bias	**Low**	**Low**	Low	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**

Table 6. Bias Table Chart

Studies comparing the amount of nickel release between, single stranded and multi stranded NTti wires manufactured by American Orthodontics, (Sheboygan, WI, USA), Ormco (Glendora, CA; Speed Supercable; Damon) showed that single stranded NiTi wires released more nickel comparatively.[20]

Blood and Periodontal Evaluation after Orthodontic Treatment in Conventional and Nickel Free Brackets - (Table 5)

Camilla et al.[21] conducted a study where their objective was to evaluate prospectively gingival and blood status in patients allergic to nickel between two groups namely, conventional brackets and nickel free brackets. An analysis of white blood cells in allergic and non-allergic patients during and after treatment showed an increase in eosinophils, monocytes and basophils. They hypothesized that these results were not related to the removal of the appliances, but rather to the extensive exposure to nickel during treatment, as there was an increase in plasma nickel concentration in both groups.

The continuous low-level stimulus of antigens such as nickel raises the level of *interleukin-4 (IL-4)* produced by T cells, regardless of whether or not an individual is allergic, which favours a polarized immune response for a *TH2* profile, with a characteristic cell and molecule population through a pathway dependent on signal transducer and activator of transcription (STAT-6) and GATA-325. It was concluded that patients who were treated with nickel-free bracket have better gingival health and comparatively smaller blood changes than those treated with conventional method. All symptoms were eliminated after the removal of the brackets.

DISCUSSION

14 articles were selected from this systematic review. The corrosion resistance of different nickel titanium orthodontic products were different because of the variation in the percentage of composition.[11] The corrosion resistance takes place in the form of ion release and it is assessed by immersing the orthodontic wires in artificial saliva at different time intervals. Regardless of the composition of metal alloys there will be corrosion taking place inside the oral environment and in some cases it can be exaggerated if there is any defect in the manufacturing process.[12] More studies regarding the release of metals during treatment and changes in the composition of alloys have been done because of the simultaneous increase in the nickel hypersensitivity and demand for orthodontic treatment. A concept called the tolerance concept has been introduced in orthodontics for the cases of nickel hypersensitivity. According to this concept, people who are exposed to orthodontic appliances in their early stages of life will be less sensitive or tolerant to nickel when they are exposed in some other metal forms e.g., ear piercing.[22] A study was conducted to assess the amount of DNA damage. When 1.18 μg of nickel exposure has happened to human gingival fibroblast samples for 72 hours, mild damage has taken place which means that the amount of nickel concentration in orthodontic appliances is capable of producing cytotoxic effects.[23] These results are in accordance with the study done by Fiorenzo Faccioni.[24] The biocompatibility of orthodontic appliances (brackets, bands, wires) can be evaluated by determining the amount of metal ion release due to corrosion, both in vivo and iv vitro studies. In in vivo studies, the behaviour of the metals can be assessed but the collection of invasive samples (like blood) is difficult since it involves the patient consent. But the other samples such as saliva, urine can be collected and assessed. It should be made clear that the results that were obtained during the orthodontic treatment is only a momentary exposure and does not indicate lifetime or chronic exposure.[5-7]

On the other hand, in vitro studies are performed in a laboratory-controlled environment but do not entirely mimic the conditions prevailing in the oral cavity. Orthodontic treatment, which includes the braces, influences the accumulation of biofilm and colonization of bacteria, thus making the patient more prone to inflammation and bleeding. Pazzini et al. found that nickel can influence inflammatory reactions throughout orthodontic treatment. Clinical features include gingival hyperplasia, changes in colour and gingival bleeding upon probing.[25] Gursoy et al.[26] in 2007 found that low-dose continuing nickel release from orthodontic appliances might be the initiating factor for gingival overgrowth, as it has the capability of increasing epithelial cell proliferation. Studies on the vascular changes in the periodontal ligament after removal of orthodontic forces showed that the pattern of blood vessel distribution in the periodontal ligament was likely to be affected by changes in the direction of tooth movement produced by the application and removal of the orthodontic force. Changes in the blood vessel number and density were associated with the direction of tooth movement.[27] Even though orthodontic appliances do not have any direct effect on general health, it is enough to produce the changes in oral mucosa in minimal or non-toxic concentration. There are many studies done previously to show that the nickel components are capable of causing lung and nasal cancer. The mechanism underlying the genotoxic potential is unknown but several pathways have been explained such as the interaction of metal with DNA, causing oxidative DNA damage or the hindrance of DNA repair and replication process. The present study has recorded significant amount of nickel release from all groups of samples. Even though there have been several studies conducted regarding the effects of nickel on periodontium, no studies have been carried out to determine the amount of nickel release that will produce carcinogenic effect. The amount of nickel and chromium release from the appliances is much less than the dietary intake but it is sufficient to produce an allergic reaction in those who are sensitive to nickel. It also can produce important biological changes in oral mucosa. Thus, care should be taken.

CONCLUSIONS

Studies show that nickel leach out reaches a maximum after 7 days and eventually diminishes with time. Maximum nickel release was from brackets and bands combined. To conclude, this systematic review has shown that nickel solution at a minimal concentration could damage human gingival fibroblast and the nickel released from the different brands of the brackets were not uniform. Since the carcinogenic effect of nickel has been established it is high time to think about other biocompatible alloys without involving the heavy metal nickel

which can be used, or to find standardization for the nickel to 'leach out' from the appliance. As much as we gain a large insight in this systematic review, there were a few limitations. More studies need to be conducted to deduce a further concise result.

Future Scope

There could be more studies conducted on the various types of NiTi wires that are constantly being introduced in the industry, and based on the updated literature, it will be easier for orthodontists to choose the right wire for a particular patient.

Abbreviations -

Ni Nickel
Cr Chromium
NiTi Nickel Titanium
DNA Deoxyribonucleic acid
TiO2 Titanium oxide
IL–4 Interleukin–4
TH2 Helper T cells
STAT Signal Transducer and Activator of Transcription

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