5. Kaiser, K. and Guggenberger, G., Mineral surfaces and soil organic matter. *Eur. J. Soil Sci*., 2003, **54**, 1–18.
6. Jastrow, J. D., Soil aggregate formation and the accrual of particulate and mineral-associated organic matter. *Soil Biol. Biochem*., 1996, **28**, 665–676.
7. Wershaw, R. L., Molecular aggregation of humic substances. *Soil Sci*., 1999, **164**, 803–813.
8. Wattel-Koekkoek, E. J. W., Van Genuchten, P. P. L., Buurman, P. and Van Lagen, B., Amount and composition of clay-associated soil organic matter in a range of kaolinitic and smectitic soils. *Geoderma*, 2001, **99**, 27–49.
9. Indraratne, S. P., Occurrence of organo-mineral complexes in relation to clay mineralogy of some Sri Lankan soils. *J. Natl. Sci. Found. Sri Lanka*, 2005, **34**, 29–35.
10. Indraratne, S. P., Goh, T. B. and Shindo, H., Sorption of organic compounds by hydroxyl-interlayered clay through chealation and humification process. *Geoderma*, 2007, **139**, 314–320.
11. Swift, R. S., Organic matter characterization. In *Methods of Soil Analysis, Part 3. Chemical Methods* (ed. Sparks, D. L.), American Society of Agronomy, Madison, 1996, pp. 1018–1020.
12. Vanlauwe, B., Swift, M. J. and Mereks, R., Soil litter dynamics and N use in a leucaena (*Leucaena leucocephala*) alley cropping system in South western Nigeria. *Soil Biol. Biochem*., 1996, **28**, 739–749.
13. Smucker, A. J. M., McBurney, S. L. and Srivastava, A. K., Quantitative separation of roots from compacted soil profiles by the hydropneumatic elutriation system. *Agron. J*., 1982, **74**, 500–504.
14. Ratnayake, R. R., Effect of soil organic matter on nutrient availability under different land use patterns with special emphasis on the role of carbohydrates. Ph D thesis, University of Peradeniya, Sri Lanka, 2006.
15. Konen, M. E., Jacobs, P. M., Burras, C. L., Talaga, B. T. and Mason, J. A., Equations for predicting soil organic carbon using loss-on-ignition for North central US soils. *Soil Sci. Soc. Am. J*., 2002, **66**, 1878–1881.
16. Siewert, C., Rapid screening of soil properties using thermogravimetry. *Soil Sci. Soc. Am. J*., 2004, **68**, 1656–1661.
17. Ratnayake, R. R., Seneviratne, G. and Kulasooriya, S. A., A modified method of weight loss on ignition to evaluate soil organic matter fractions. *Int. J. Soil Sci*., 2007, **2**, 69–73.
18. Curve expert 1.3, A comprehensive curve fitting system for Windows. 112B, Crossgate Street, Starkville, MS 39759, 1995–1997.
19. Atkins, P. W., *Physical Chemistry*, Oxford University Press, Oxford, 1998.
20. Cambardella, C. A., Gajda, A. M., Doran, J. W., Wienhold, B. J. and Kettler, T. A., Estimation of particulate and total organic matter by weight loss-on-ignition. In *Assessment Methods for Soil Carbon* (eds Lal, R. *et al*.), Lewis Publishers, CRC Press, Boca Raton, 2001, pp. 349–359.
21. Kerek, M., Drijber, R. A., Powers, W. L., Shearman, R. C., Gaussoin, R. E. and Streich, A. M., Accumulation of microbial biomass within particulate organic matter of aging golf greens. *Agron. J*., 2002, **94**, 455–461.
22. Van Camp, N., Nachtergale, L., Zahedi, G., Muys, B., Lust, N. I. and Van Meirvenne, M., Assessing partial variability of soil carbon in a mixed forest using kriging interpretation, 2001; www.bib.fsagx.ac.belcoste21/ftp/2001-04-26/vancamp-sum-pdf
23. Six, J., Christian, F., Denef, K., Ogle, S. M., de Moraes Sa, J. C. and Albrecht, A., Soil organic matter, biota and aggregation in temperate and tropical soils – Effects of no-tillage. *Agronomie*, 2002, **22**, 755–775.
24. Cai, Y., Gafney, S. H., Lilley, T. H., Magnolato, D., Martin, R., Spencer, C. M. and Haslam, E., Polyphenol interactions. Part 4. Model studies with caffeine and cyclodextrins. *J. Chem. Soc. Perk*., 1990, **T2**, 2197–2208.

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On the mathematical significance of the dimensions of the Delhi Iron Pillar

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The dimensions of the 1600-year-old Delhi Iron Pillar have been re-analysed in light of new scholarship on the traditional Indian unit of measurement. The dimensions of the pillar can be well reconciled considering the basic unit of measurement as 17.63 mm. The low percentage errors between the theoretical and actual measurements provide further support to this analysis. The significant mathematical ratios embedded in the relative dimensions of the pillar have also been set forth. The close association of the basic unit of measurement and the mathematical ratios with those of the Harappan civilization offers evidence for continuity of scientific ideas and traditions from the Harappan civilization to the Ganga civilization. Analysis of dimensions of the characters of the Gupta–Brahmi inscription revealed the possible use of the decimal system.

Keywords: Delhi Iron Pillar, dimensional analysis, mathematical significance, Harappan civilization.

THE dimensions of the Delhi Iron Pillar have been measured in great detail by Beglar[1] and Ghosh[2]. These available dimensions have been analysed earlier by Balasubramaniam[3] to show the inherent symmetry in the design of the pillar, by considering the rough bottom portion to be buried underground during its original erection at Udayagiri. The relative proportion of the various parts of the pillar was understood. The decorative bell capital is one-third of the cylindrical portion of the pillar above the ground and one-fourth of the total height of the pillar above the ground. The height of the decorative bell capital was also equal to the depth of burial below the ground. When the overall dimensions of the pillar were analysed[3], it was pointed out that one could relate the dimensions of the pillar to the unit of modern inch, which was called *U* (see figure 3 in Balasubramaniam[3]). This is equal to 25.40 mm.

A detailed statistical analysis of available length measurements of several Harappan civilization cites by Danino[4,5] has revealed recently that the basic Harappan unit of measurement (traditionally referred in India as ‘angulam’) measured 17.63 mm. The angulam that was in use in the Harappan civilization continued all the way to later periods in Indian history, certainly up to the classical period[4,5]. Danino has further shown by a simple procedure and without any a priori assumptions[4,5], that the largest possible unit to measure Harappan town plans, such that the dimensions could be expressed as integral multiples,

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measured 1904 mm. This is 108 times the measure of angulam taken as 17.63 mm. Danino[4] has cited several literary evidences to show that '108 angulam' was a traditional measure and concept in classical India. He has identified this unit of 1904 mm with the traditional 'dhanus'. It is interesting to note that the number 108 is held sacred in classical Hinduism, initially because of astronomical reasons[6].

The proposal of Danino is indirectly confirmed from a terracotta scale from Kalibangan where the unit of 17.5 mm was obtained[7], and from a ivory scale from Lothal where the unit of 17.7 mm was obtained[8]. The shell scale from Mohenjodaro[9] is a broken piece of shell with divisions of 6.706 mm, while the bronze scale from Harappan[10] is in the form of a rod with divisions of 9.34 mm. There is a view that these broken pieces of shell and bronze may not be scales at all[9]. Nevertheless, the connection between various units in the known scales of Harappan civilization, excluding the Kalibangan scale which was reported only recently[7], has been discussed by Mainkar[11].

Since the Delhi Iron Pillar was constructed as a standard of Vishnu (i.e. *Vishnuordhvaja*), as clearly mentioned in the Gupta–Brahmi Sanskrit inscription on the pillar[12], it would be interesting to explore the dimensions of the pillar in light of this new scholarship on the traditional unit of measurement, the angulam, measuring 17.63 mm. This communication will revisit the dimensional analysis, both the macro- and micro-dimensions, in view of new scholarship[4–6]. Microdimensions refer to the dimensions of the characters of the oldest inscription on the pillar. This analysis will provide insights into standard length measure and, indirectly, the mathematical knowledge that existed during the Gupta period, because the Delhi Iron Pillar is truly a significant engineering achievement of this golden period in Indian history.

Considering the traditional Indian angulam to be 17.63 mm and that 108 angulams made a dhanus (i.e. 108 × 17.63 mm = 1904 mm), and the known dimensions of the pillar[1,2], it is now possible to convert the dimensions of the Delhi Iron Pillar into units of Indian angulam (*A*) and dhanus (*D*). This has been performed and the end result is shown in Figure 1.

The striking feature of the analysis is that the dimensions of the pillar match remarkably well with the units of angulam and dhanus of the Harappan civilization; for example, the total height of the pillar is precisely 4 dhanus. In order to bring out the accuracy and relevance of the dimensions noted in Figure 1, the dimensions mentioned in this figure in units of dhanus have been compared with the actual measured dimensions of the Delhi Iron Pillar (Table 1). The measurements of Ghosh[2] have been used in this table. Ghosh reported his measurements in inches and each modern inch was considered as 2.54 cm. Each angulam was taken as 1.763 cm. Further, 108 angulams equalled 1 dhanus. In two of the entries in Table 1, the height of the *chakra* (that originally crowned the decorative bell capital) is taken as 20 inches in diameter[13,14]. A noteworthy feature of Table 1 is the low error margin between the proposed and measured dimensions, in most cases. The percentage error is defined as the deviation of the actual measurement from the proposed measurement, expressed in terms of percentage of the proposed measurement.

It may be noted at this juncture that even if the angulam had been taken as 1.75 cm based on the markings seen on the Kalibangan terracotta scale[7] or 1.77 cm based on the markings seen on the Lothal ivory scale[8], the errors would have been similarly low.

It is therefore clear that the ancient Indian unit of measurement, dhanus, that was utilized in the Harappan civilization was used in the design of the Delhi Iron Pillar. The dimensions of the decorative bell capital[15] of the pillar can be similarly re-analysed in light of new scholarship on the traditional Indian unit of measure, the angulam. This is not attempted here, but left to some interested reader.

The finding of the present study is a solid addition to the growing body of evidence that Harappan techniques,

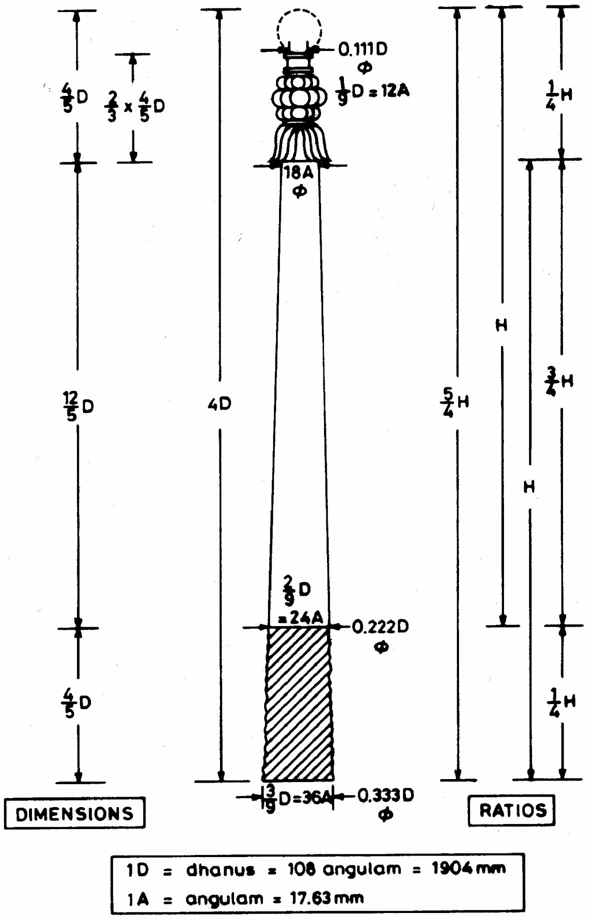

Figure 1. Dimensions of the Delhi Iron Pillar analysed in terms of angulam (=17.63 mm) and dhanus (=108 angulams = 1904 mm). The significant ratios that are evident in the relative dimensions of the pillar are mentioned on the right.

Table 1. Comparison of proposed and actual dimensions of the Delhi Iron Pillar. For the calculations, each modern inch was considered as 2.54 cm and each angulam was considered as 1.763 cm. Further, 108 angulams = 1 dhanus

Location	Proposed length in terms of unit		Theoretical measurement (cm)	Actual measurement (cm)	Error (%)
	Dhanus *D*	Angulam *A*			
Diameter at extreme bottom	3/9	36	63.47	62.46	–1.59
Diameter at start of smooth section	2/9	24	42.31	42.42	+0.26
Diameter of cylinder at the very top	1/9	12	21.16	20.32	–3.97
Height of the rough portion	4/5	86.4	152.32	154.98	+1.75
Height of the smooth portion	12/5	259.2	456.97	457.15	+0.04
Height of decorative bell capital without *chakra*	2/3 × 4/5	64.8	114.24	104.14	+2.55
Height of capital with *chakra*	4/5	86.4	152.32	154.94	+1.72
Total height of the main body	16/5	345.6	609.30	612.18	+0.47
Total height of the pillar with *chakra*	4	432	761.62	767.08	+0.72

crafts, ornaments, art forms, customs, rituals and religious beliefs were transmitted virtually unchanged from the Harappan civilization to the Ganga civilization[16,17]. There is a need to carefully obtain the dimensions of significant historical objects and structures, and relate them to the traditional units. This will certainly throw further insights on the units that were in use through the ages. It must be borne in mind that variations are expected in different regions or times because a unique standard for all time and places is hardly likely.

It is indeed fascinating that the unit of measurement that was used in the planning of Harappan civilization settlements is also realized in the dimensions of the Delhi Iron Pillar, thereby establishing the continuity of scientific ideas and traditions from the Harappan civilization (3000–1600 BC) down to later periods in Indian history, certainly at least up to the Gupta period (AD 320–600). Considering Dholavira's date from the Mature Harappan period of 2000 BC and the date of the Delhi Iron Pillar of AD 402, this implies an almost continuous unbroken tradition stretching more than 2400 years.

A careful analysis of the relative proportions of the pillar reveals some interesting ratios, which will be dealt in a little detail below.

The height of the complete decorative bell capital (4/5 *D*) is one-third of the exposed height of the main body of the pillar above the ground (12/5 *D*). Further, the decorative bell capital is itself divided such that the decorative bell capital without the *chakra* (circular disc) is two-thirds of the total height of the complete bell capital. The *chakra* that originally topped the bell capital[13,14] was one-third of the total height of the decorative bell capital. Therefore, the division of the major section of the pillar above the ground proceeds in thirds, such that the height of the *chakra* at the very top was one-third of that of the decorative capital, and the height of the entire decorative capital was one-third of that of the cylindrical main body of the pillar, originally exposed above the ground.

The original depth of burial below the ground was 4/5 *D*, which is one-third of the main body of the pillar above the ground (12/5 *D*). The depth of burial was equal to the height of the complete decorative bell capital, as pointed out earlier[3].

This division by thirds is also noted in the diameter of the pillar at three significant locations, namely the base (1/3*D* = 3/9*D* = 0.333*D*), the start of the smooth section at the ground level of the original burial level (2/9*D* = 0.222*D*) and the cylinder at the top of the capital (1/9*D* = 0.111*D*). It is also remarkable that there is considerable match between the proposed theoretical and actual measurements in case of these three diameters, as can be noted in Table 1.

Interestingly, the same concept of division by three is noted in the design of the Dhar Iron Pillar[18], dated to the 11th century AD. This pillar is not standing erect at present, but lying in three broken pieces on a raised platform. In its original condition, the Dhar Iron Pillar was almost twice the height of the Delhi Iron Pillar. The lower square section converts to an octagonal section (whose length is one-third that of the square section) and the octagonal section tapers to a round section at the top (whose length was originally one-third of the octagonal section, but is now partly broken).

The above analysis again shows the continuity of ideas from the Harappan civilization down to later periods in Indian history because detailed analysis of dimensions of Harappan settlements has revealed that the number three is key to the design of Harappan cities[4,5].

There are several other interesting ratios noticed in the dimensions of the pillar. A few important ones will be elucidated here. A complete analysis may require analysis by experts in mathematical sciences. Based on the dimensions listed on the left in Figure 1, some significant ratios evident are 1/4, 2/4 (or 1/2), 3/4 and 5/4. Interestingly, these ratios were significant in the Harappan civilization because it is now known that the relative proportions of major buildings and design of Harappan cities were based on some notable ratios[4,5,19]. A ratio that was particularly significant was 5/4, which is evident from the design of Harappan settlements[4,5]. The importance of this ratio in the design of structures, according to Indian traditions of

Vastu Shilpa has been discussed in detail elsewhere[4,5]. This important ratio is not directly obvious, but can be derived based on analysis of the relative dimensions of the overall length of the pillar and the height above the ground. It is noted that if one considers the height above the ground (i.e. above the original burial level) as H, the overall Pillar measures 5/4 H (see right side of Figure 1). Incidentally, H is also the height of the main cylindrical body of the pillar, excluding the bell capital, when one considers the dimension of the pillar from the bottom to the top of the cylindrical section. The appearance of this important ratio of 5/4 in a subtle manner in the dimensions of the Delhi Iron Pillar is noteworthy. This further reinforces the concept that scientific ideas and traditions that originated in the Harappan civilization continued to later periods in Indian history.

It may be mentioned that the fabrication of the pillar was a highly specialized activity and its dimensions would have been planned precisely from the start. It is clear that the designers of the pillar started out by designing the entire structure to equal $4D$. Then they went about dividing the different sections of the pillar in a precise manner, maintaining symmetry and keeping philosophical aspects regarding ratios in mind.

Attention is now focused on the microdimension as available on the inscriptions. It has been shown elsewhere that the inscription was put on the surface of the pillar when the pillar was in the vertical direction, sometime after its initial erection[20]. Further, it is known based on a detailed analysis of the Gupta–Brahmi inscription on the pillar that the King Chandra, whose exploits are extolled in the verses, was alive when the long inscription was inscribed[21]. Chandra has been identified as Chandragupta II Vikramaditya[21], whose known dates are between AD 375 and 413, based on analysis of archer-type gold coins of the Imperial Guptas. Therefore, the dimensions (macro and micro) of the pillar provide information about the units that were used during this period. It has been shown above that the traditional basic units of angulam and dhanus can be used to describe the overall (macroscopic) dimensions of the pillar.

When the dimensions of some of the characters of the Gupta–Brahmi inscription (dated palaeographically[21], i.e. on the nature of the script, to early 5th century AD) were analysed, it was realized[20] that the unit of measure that could explain the spacing of the characters as well as the width, breadth and length of each character was precisely 19.03 mm. This has also been shown by statistical analysis of estimated distances from four characters of the Gupta–Brahmi inscription on the pillar[20]. This unit of 19.03 mm was related to the unit of angulam proposed in earlier references[22], before the finding of Danino[4,5] was known to the present author. This was taken as reasonable because 19.03 mm is precisely three-fourths of the modern inch of 25.4 mm. It would now be interesting to relate the unit of 19.03 mm to the angulam and dhanus. It is immediately evident that 19.03 mm is equivalent to 100th division of the dhanus, namely 1904/100 mm. This brings us to another fascinating conclusion that the basic unit used for the inscription was exactly 1/100th of one dhanus. This appears to hint that a second unit of measure was also in use during the Gupta period and this basic unit appears to have measured 1/100th of a dhanus.

The traditional system of measurement that originated in the Harappan civilization was based on the concept of progressive sequence of ratios, like 1/16, 1/8, 1/4, 1/2, 3/4, 4/4 and so on. The system of dividing and multiplying by 10s distinguishes the decimal system. The Harappan use of decimal system is well known in the weight systems and also in the scales of the Harappan civilization[4,5]. This was an empirical system and there was no need for numerals with decimal place value and the concept of zero. The concept of zero is supposed to have originated from India and the dates mentioned[23] are 4th or 5th Century AD. Based on the finding of the present study that the basic unit of measurement used for the Delhi Iron Pillar inscription is precisely 1/100 (or 0.01) of the dhanus that was in use in the Gupta Period, it is reasonable to hypothesize that the system of division by 10s seems to have become prevalent by the time the inscription was put on the surface of the Delhi Iron Pillar, suggesting the possibility that the decimal system was known in India by early 5th Century AD, the time the inscription was inscribed on the pillar[21]. Additional valuable inputs can be obtained from careful measurements of the dimensions of all the characters of the Gupta–Brahmi inscription. This can easily be performed by non-destructive means, using modern surface profiling technology[24].

The basic unit of measurement that existed during the Gupta Period has been understood by re-analysing the dimensions of the Delhi Iron Pillar, utilizing the value of angulam (basic Indian unit of measure) derived from Harappan civilization. This basic unit measured 17.63 mm. The low error margins between the proposed dimensions and the actual measurements further validate the use of this unit for describing and understanding the Gupta Period Iron Pillar. The present analysis suggests a direct connection between the basic unit of measure of the Harappan civilization (i.e. the Harappan civilization angulam) and the basic unit of measure of the Delhi Iron Pillar (i.e. the Gupta Period angulam). The significant mathematical ratios embedded in the relative dimensions of the pillar have also been highlighted, taking special note of the importance of the ratio 5/4. Analysis of dimensions of the characters of the Gupta–Brahmi inscription has hinted at the possible use of the decimal system.

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1. Beglar, Y. D., Report for the year 1871–72. Archaeological Survey of India Annual Reports, 1874, vol. IV, pp. 28–30.
2. Ghosh, M. K., The Delhi Iron Pillar and its iron. *Natl. Metall. Lab. Tech. J.*, 1963, **5**, 31–45.

3. Balasubramaniam, R., New insights on the corrosion of the Delhi Iron Pillar based on historical and dimensional analysis. *Curr. Sci*., 1997, **73**, 1057–1067.
4. Danino, M., Dholavira's geometry: A preliminary study. *Puratattva*, 2005, **35**, 76–84.
5. Danino, M., New insights into Harappan town-planning, proportions, and units, with special reference to Dholavia. *Man Enviorn*., 2008, **33**, 66–79.
6. Kak, S., *The Astronomical Code of the Rgveda*, Munshiram Manoharlal, 2000, pp. 101–124.
7. Balasubramaniam, R. and Joshi, J. P., Analysis of terracotta scale of Harappan civilization from Kalibangan. *Curr. Sci*., 2008, **95**, 588–589.
8. Rao, S. R., *Lothal: A Harappan Port Town*, Manager of Publication, Government of India Press, New Delhi, 1955–62, vol. II, pp. 689–690.
9. Mackay, E. J. H., *Further Excavation at Mohenjodaro*, Manager of Publication, Government of India Press, New Delhi, 1938, pp. 601–611.
10. Vats, M. S., *Excavation at Harappa*, Manager of Publication, Government of India Press, New Delhi, 1940, pp. 365–366.
11. Mainkar, V. B., Metrology in Indus Civilization. In *Frontiers of the Indus Civilization* (eds Lal, B. B. and Gupta, S. P.), Books and Books, New Delhi, 1984, pp. 141–152.
12. Balasubramaniam, R., *Delhi Iron Pillar – New Insights*, Indian Institute of Advanced Studies, Shimla and Aryan Books International, New Delhi, 2002, pp. 23–46.
13. Balasubramaniam, R., Dass, M. I. and Raven, E. M., On the original image atop the Delhi Iron Pillar. *Indian J. Hist. Sci*., 2004, **39**, 177–203.
14. Balasubramaniam, R. and Dass, M. I., On the astronomical significance of the Delhi Iron Pillar. *Curr. Sci*., 2004, **86**, 1134–1142.
15. Balasubramaniam, R., Decorative bell capital of the Delhi Iron Pillar. *J. Metals*, 1998, **50**, 40–47.
16. Kenoyer, J. M., *Ancient Cities of the Indus Valley Civilization*, Oxford University Press, 1998.
17. Lal, B. B., *The Saraswati Flows On: The Continuity of Indian Culture*, Aryan Books International, New Delhi, 2002.
18. Balasubramaniam, R., A new study of the Dhar Iron Pillar. *Indian J. Hist. Sci*., 2002, **37**, 115–151.
19. Bisht, R. S., Dholavira and Banawali: Two different paradigms of the Harappan city forms. *Puratattva*, 1999, **29**, 14–37.
20. Balasubramaniam, R. and Prabhakar, V. N., On technical analysis of characters of the oldest Delhi Iron Pillar inscription. *Curr. Sci.*, 2007, **92**, 1709–1719.
21. Balasubramaniam, R., Identity of *Chandra* and *Vishnupadagiri* of the Delhi Iron Pillar inscription: Numismatic, archaeological and literary evidence. *Bull. Met. Mus*., 2000, **32**, 42–64.
22. Raju, L. and Mainkar, V. B., Development of length and area measures in South India. *Metric Meas*., 1964, **7**, 3–12.
23. Shukla, K. S. and Sharma, K. V., *Aryabhatiyam*, Indian National Science Academy, New Delhi, 1976, p. 119; 162.
24. Li, Y. and Gu, P., Free-form surface inspection techniques – state of the art review. *Comp.-Aided Des*., 2004, **36**, 1395–1417.

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Determination of calcium dose for minimizing fluoride bioavailability in rabbits

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Fluorosis results from excess fluoride ingestion and is characterized by marked abnormalities of bones and teeth. Most of the absorbed fluoride from the diet and drinking water can readily enter into the bones and teeth thus the bones become hypertropic and coarse but are fragile. Earlier studies indicated that calcium binds with fluoride forming an insoluble calcium fluoride in the gastrointestinal tract; thus the adverse effect of fluorosis may decrease. Quantification of calcium needed to reduce excess fluoride absorption is necessary for the treatment of fluorosis. In this study different doses of calcium in the form of calcium carbonate were administered to albino rabbits and it was observed that significant decrease in fluoride bioavailability was observed in the group of animals administered with 11.4, 14.3, 17.2, 21.4 and 50 mg calcium per kg body wt. This calcium dose level is equivalent to 1200, 1500 and 3500 mg of calcium required for a 70 kg body wt human beings.

Keywords: Absorption, bioavailability, calcium carbonate, fluoride, fluorosis.

THE primary adverse effects associated with chronic, excess fluoride intake are dental and skeletal fluorosis[1]. There is much evidence in the literature indicating a decreased fluoride concentration and a greater faecal excretion of fluoride when sodium fluoride was administered with high calcium diet[2,3]. Prevention of gastrointestinal absorption of fluoride by calcium is due to the formation of insoluble calcium fluoride accounted for a decreased serum fluoride level in calcium carbonate-treated animals[4]. Calcium supplementation does not promote urinary excretion of fluoride because in earlier studies no significant changes were observed in the concentration of urine when animals received sodium fluoride and calcium-supplemented diet[2,3]. Amount of calcium required to reduce excess fluoride was studied in the present study using albino rabbits. Rabbits were chosen because they are small yet large enough to permit blood samples to be withdrawn over the course of several hours and also rabbits are mammalian type of species, so the absorption trend may be similar to human beings. Albino rabbits were also used in earlier studies to elucidate the fluoride absorption[5,6]. Some of the important pharmacokinetic parameters like percentage of fluoride absorption, elimination half

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